The Bartlett School of Graduate Studies, University College London

Can the Portuguese National Plan for Energy Efficiency (PNAEE) reduce CO_2 emissions of Bairro de Alvalade by 60% by 2050?

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ABSTRACT

Climate Change is a real and present danger which is by in large being caused by anthropogenic greenhouse gases (GHG) emissions. The international community has shown that it is aware of the need for urgency in addressing the causes of climate change and through the Kyoto Protocol, industrialized countries, at least those that have ratified it, have agreed to reduce GHG emissions by 5% based on 1990 levels between 2008 and 2012.

Currently the largest contributing anthropogenic GHG to Climate Change is widely considered to be carbon dioxide (CO_2) representing about 77% of the total emissions. (IPCC 2007). Furthermore most CO_2 emissions are caused by the production of energy. Accordingly, to reach the target established under Kyoto, many countries have established and directed the core of their policies and measures to overhaul their energy requirements and production.

There are some countries leading the way in this matter and implementing policies that will go further than the first commitment period such as Japan, the UK, France, the Netherlands aiming for a far more ambitious target of reducing CO_2 emissions in 2050 by 60%.

Portugal too, in 2002, has ratified the Kyoto Protocol and is committed on limiting the growth of its GHG emissions by 27% by 2012 based on 1990 levels. (Ferreira *et al.* 2008 pg4) Furthermore it has created a set of policies to help reduce emissions; however current targets focus solely on 2012 and ignore any longer term scenarios. One of the policies is the National Plan for Energy Efficiency (PNAEE) that was released this year, 2008. The plan set a group of measures to help improve energy efficiency between the period 2008 and 2015.

The purpose of this study is to determine if the measures proposed by the PNAEE are capable of achieving the same level of reductions of CO_2 emissions that are the target for more ambitious countries like the UK, namely achieving a 60% reduction by 2050. The plan was implemented and tested on a chosen area of Lisbon, an experimental purpose built urbanization of the 1950's – *Bairro de Alvalade*. The urban area was studied and modelled to determine its current and future (2050) total CO_2 emissions. It was found that although the plan has a positive effect on emissions and energy consumption it is far from sufficient to reduce CO_2 emissions in 2050 by 60% and is therefore inadequate to tackle such ambitious commitments if ever considered.

60% on CO_2 reduction by 2050 are though achievable if great improvements are implemented in all houses in order to reduce energy demand and also if the energy consumed is provided by a high percentage of renewables.

Ambitious targets are possible to be reached but it takes major changes in houses characteristics, energy use and energy production.

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1.1 CLIMATE CHANGE

*"**Climate change**" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."* (UNFCCC 2008)

According to the scientific community, that assesses the Intergovernmental Panel on Climate Change (IPCC), over the last century the mean surface temperature of the earth has risen by about 0.6ºC. (IPCC 2001) Furthermore if it rises by more than 2ºC above pre-industrial levels, it may become irreversible. (EC 2007 pg 7) The consequences from a rise in temperature are many and diverse and include: disruption of ecosystems, threatening water supplies, food security, health threats and rising sea levels that may put entire cities at risk. There is strong evidence supporting climate change and scientists are convinced that greenhouse gas emissions due to human activities are the cause of this warming. (IPCC 2001) *"Human activities have changed the chemical composition of the atmosphere"*. (Dow and Dowing 2007 pg 9) Human activities contributed to the substantial increase of greenhouse gases (GHG) emissions to the atmosphere causing the earth surface and atmosphere warming which affects natural ecosystems and humanity.

According to the Fourth Assessment Report from the IPCC, global GHG emissions increased 70% between 1970 and 2004. The most important anthropogenic GHG is considered to be carbon dioxide (CO_2). CO_2 emissions have grown by about 80% from 1970 to 2004 (21 to 38 Gt) and in 2004 represented 77% of the anthropogenic GHG emissions. Most of the CO_2 emissions derive from fossil fuel combustion to generate energy. (IPCC 2007)

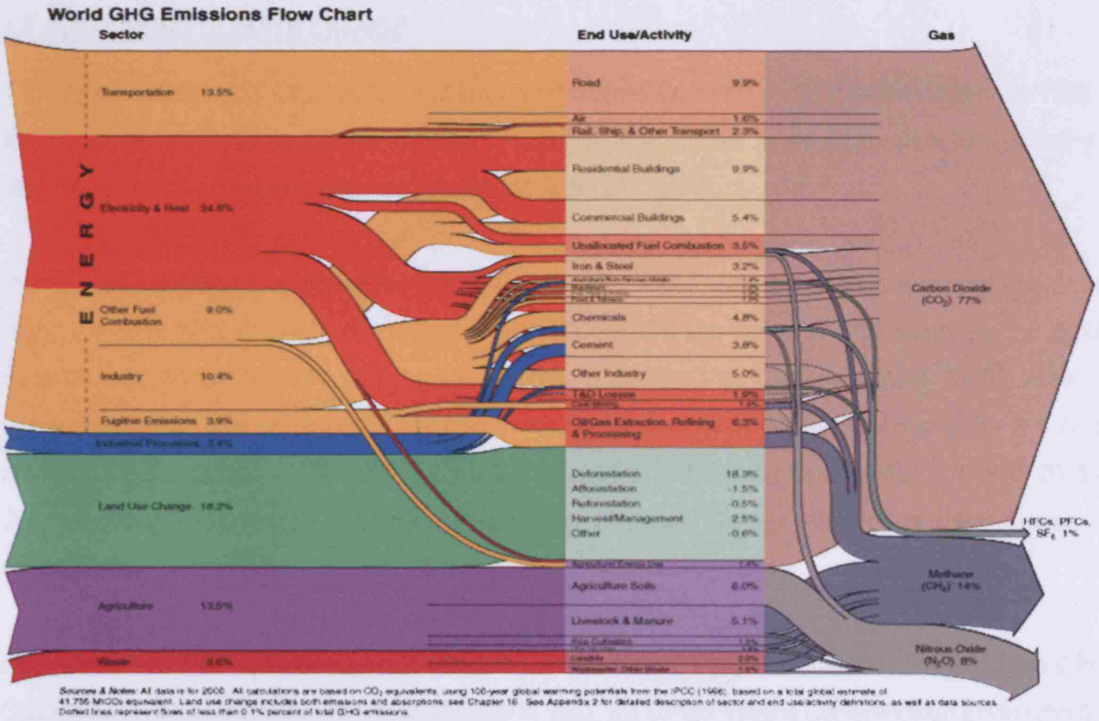


Figure 1.1: World Greenhouse gases Emissions Flow Chart 2000 (WRI 2008)

From pre-industrial period CO_2 emissions increased from 280ppm (part per million) to 379ppm in 2005, and are increasing every year at an approximate rate of 1.9ppm (1995-2005). Whilst CH_4 concentrations increased between the early 90s and 2005 from1732ppb to 1774ppb and N_2O since pre-industrial to 2005 from 270ppb to 319ppb (IPCC 2007). If measures are not implemented to limit CO_2 emissions, the atmospheric levels may rise between 540 and 970 ppmv by 2100. (Boyle *et al.* 2004)

World and Europe anthropogenic GHG emissions

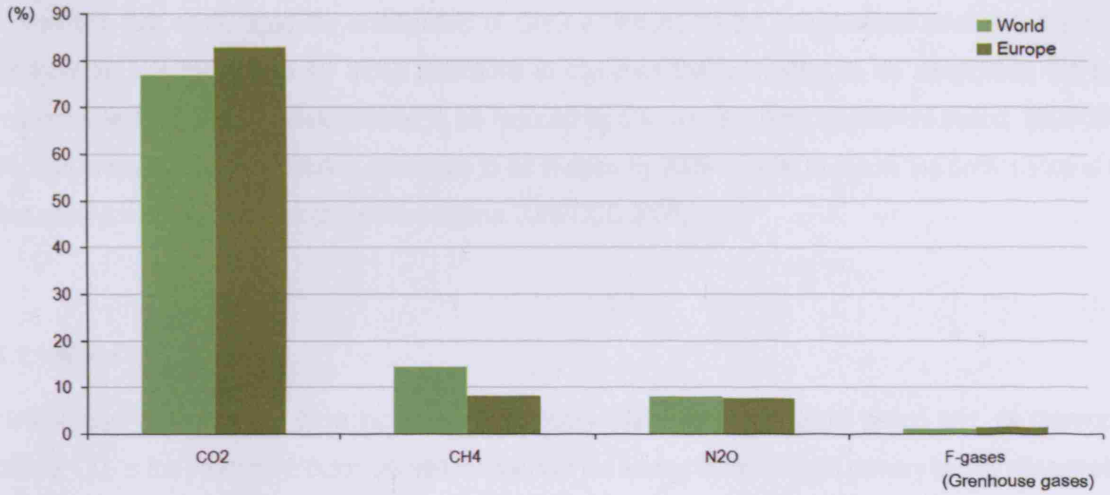


Figure 1.2: World and Europe: Share of different anthropogenic GHGs in total emissions in terms of CO_2e (World data from 2004 (IPCC 2007) and Europe data from 2006 (EU 2008))

1.2 ADDRESSING CLIMATE CHANGE

The World Meteorological Organization and the United Nations Environment Programme created, in 1988, the Intergovernmental Panel on Climate Change (IPCC), *"an international forum responsible for assessing the scientific evidence of climate change and its impacts."* (EC 2007 pg 7)

In 1990, this scientific group presented their first assessment report stating *"that global warming was real and urged that something should be done about it."* (UNFCCC 2008) and that, over 60% immediate (1990) GHG reduction from human activities were required in order to stabilise their concentrations at 1990's levels. The group of scientists also predicted an increase on global mean surface temperature during the 21st century around 0.3ºC per decade. (IPCC 1990) After this first report, a further three were released, in 1995, 2001 and 2007, all stating the confidence and proof of the existence of Climate Change enhanced by anthropogenic GHG emissions.

Based on the scientific evidence, governments created the United Nations Framework Convention on Climate Change (UNFCCC) which held it's first conference in 1992, the United Nations Conference on Environment and Development – "Earth Summit", in Rio de Janeiro. (UNFCCC 2008)

It was more then a decade ago that most countries joined UNFCCC, the international treaty where the first concerns on what should be done to reduce global warming was addressed. The Convention on Climate Change set an overall framework for intergovernmental efforts to undertake the challenge posed by climate change. It recognizes that the climate system is a shared resource who's stability can be affected by emissions of carbon dioxide and other GHG. The Convention enjoys universal membership, with 192 countries having ratified in 1992 and entered into force on 21 March 1994. (UNFCCC 2008)

In 1997 a number of nations approved another treaty, the Kyoto Protocol, linked to the UNFCCC. Whilst the Convention just encouraged the stabilization of GHG emissions by the industrialised countries, the Kyoto Protocol set out the targets for those reductions to countries that committed to do so. Against the base reference level of 1990, emissions have to be reduced by 5% over the first commitment period, 2008-2012. Though, a multilateral framework is necessary to be in place by 2009 in order to assure the continuance of the first commitment period by another similar regime. (UNFCCC 2008)

1.2.1 World

Greenhouse gas emissions have increased dramatically since the pre-industrial period and, as mentioned before, CO_2 is the major contributor, derived mainly from the energy sector. Global primary energy consumption has been increasing from year to year at a much faster rate than, for instance, the worlds' population. (Boyle *et al.* 2004)

Regional Consumption pattern 2007

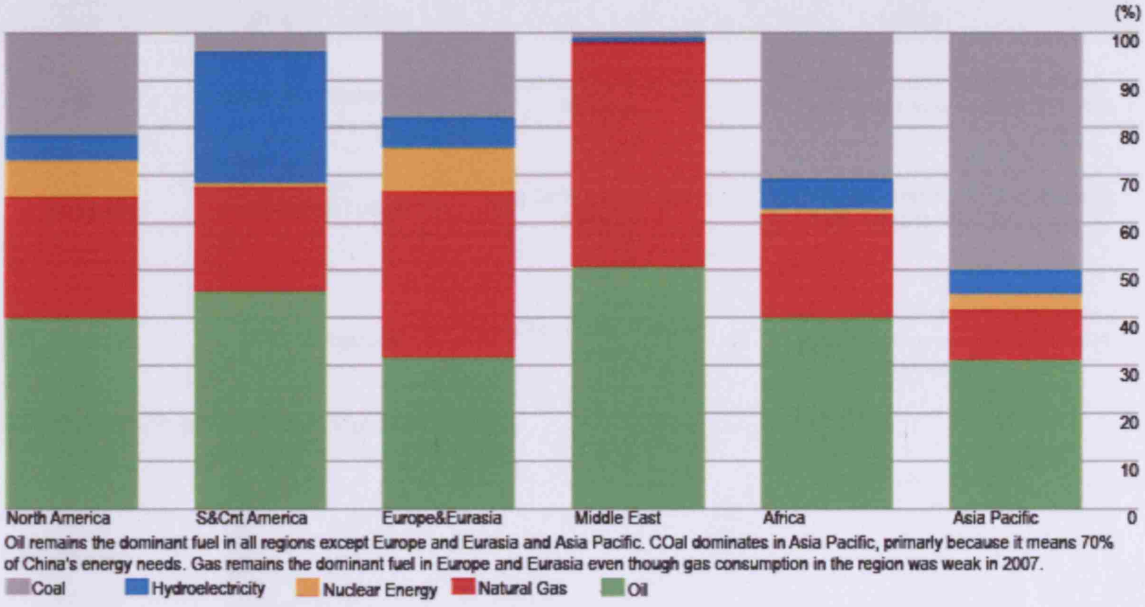


Figure 1.3: Regional consumption pattern 2007 (BP 2008)

Addressing climate change is consequently a need to address energy use and production, from primary to useful energy. The way humanity uses energy sources is extremely inefficient. *"Only about one third of the energy content of the fuel the world uses emerges as 'useful' energy."* (Boyle *et al.* 2004 pg 35) There is therefore, a great potential to improve the energy system efficiency, from generation to supply and demand by improving the system technology and by changing life standards and lifestyles. (Boyle *et al.* 2004). In this context, the international community has produced some studies on energy future – energy supply pressure, demand pressure, governments intervention, involvement and cooperation; creating long-term scenarios (50 – 100 years) of options for energy future. (WEC 2007)

Many countries have established and directioned their measures and policies according to their current energy requirements and production capabilities by acknowledging the urgency of the situation. For example, Japan, since the first IPCC assessment report in 1990 that confidently proved that Climate Change exists, started to implement energy efficiency policies which made the country achieve one of the lowest primary energy consumption rates in the world. (Hendel-Blackford *et al.* 2007) The fact, that the country is scarce in energy sources drove the community to embrace an energy efficient philosophy. This has led them to become one of the leading countries on energy efficiency. *"The political support for emissions reductions and energy efficiency is high".* In 2007, the Prime Minister expressed an ambitious target to reduce global emissions by 50% by 2050 by all countries in the world. (Hendel-Blackford *et al.* 2007 pg10) Japan is one of the greatest emitters of CO_2 nevertheless, *"the National Institute for Environmental Studies and the Kyoto University are jointly assessing a 60 to 80% GHG reduction by 2050."* (Anon 2008)

Country	Organization	Report/Project	Emission Target
Japan	Japan Atomic Industrial Forum	2050 Nuclear Vision and Roadmap	60% reduction in CO2 emissions relative to 2010 level (based on Kyoto Protocol) in 2050
Australia	The Australia Institute	Long-Term Greenhouse Gas Scenarios	60% reduction in national GHG emissions by 2050 relative to 1998-1999 levels
Australia	WWW Australia et al	A Clean Energy Future for Australia	0% reduction in national CO2 emissions from the stationary energy sector relative to 2001 level bay 2040

Table 1.1: World – Projects Long Term (Anon 2008)

1.2.2 Europe

For European countries, the Kyoto Protocol allows for the European Community and its State Members to achieve their commitments together. Therefore, the European Climate Change Programme was created in 2000, by the European Commission, which established that the European Union has to reduce 8% of GHG emissions based on 1990 values. With the first commitment period starting in 2008, in March 2007 the EU

endorsed an integrated energy and climate change policy. This initiates a period of a new industrial revolution to transform the way we produce and use energy, and the types of energy we use. (EC 2007)

Having to limit global warming to 2ºC, GHG emissions will have to stop increasing in the next 10 to 15 years and then, based on 1990 levels, decrease by about half by 2050. The European Union (EU) considers that, globally, industrialized countries should decrease GHG emissions by 20% by 2020. (EC 2007)

Member States	1990	Kyoto Protocol base year	2006	Targets 2008-2012 under Kyoto Protocol and 'EU burden sharing'
	(million tonnes)	(million tonnes)	(million tonnes)	(%)
Austria	79,2	79	91,1	-13
Belgium	144,5	145,7	137	-7,5
Denmark	69	69,3	70,5	-21
Finland	70,9	71	80,3	0
France	563,3	563,9	541,3	0
Germany	1227,7	1232,4	1004,8	-21
Greece	104,6	107	133,1	25
Ireland	55,5	55,6	69,8	13
Italy	516,9	516,9	567,9	-6,5
Luxemburg	13,2	13,2	13,3	-28
Netherlands	211,7	213	207,5	-6
PORTUGAL	**59,1**	**60,1**	**83,2**	**27**
Spain	287,7	289,8	433,3	15
Sweden	72	72,2	65,7	4
United Kingdom	768,5	776,3	652,3	-12,3
EU-15	4243,8	4265,5	4151,1	-8
Bulgaria	116,7	132,6	71,3	-8
Cyprus	6	not applicable	10	not applicable
Czech Republic	194,2	194,2	148,2	-8
Estonia	41,6	42,6	18,9	-8
Hungary	98,2	115,4	78,6	-6
Latvia	26,5	25,9	11,6	-8
Lithuania	49,5	49,4	23,2	-8
Malta	2,2	not applicable	3,2	not applicable
Poland	453,6	563,4	400,5	-6
Romania	247,7	278,2	156,7	-8
Slovakia	73,7	72,1	48,9	-8
Slovenia	18,6	20,4	20,6	-8
EU-27	5572,2	not applicable	5142,8	not applicable

Table 1.2: Annual European Community greenhouse gas inventory 1990-2006 (EU 2008)

The European Climate Change Programme (EPPC) developed about 40 policies and measures to reduce GHG emissions and besides this, each EU country has developed its own in several sectors. (EC 2007)

All Member States have to implement the EU Directives, however, timing and methods vary from country to country as some of the policies are implemented and incorporated in policies adapted to national context. (Hendel-Blackford *et al.* 2007)

The EU target of stabilizing GHG atmospheric concentration of 450-550 ppmv CO_2 and temperature rise of 2ºC by 2050 is becoming an international aim as demonstrated above with the example of Japan's and Australia's willingness to reduce CO_2 emissions by 60% by 2050. In Europe, some countries have also developed long-term scenarios and strategies such as the UK, Germany and France (60%, 80% and 75% reductions respectively). (Anon 2008)

Country	Organization	Report/Project	Emission Target
UK	Royal Commission on Environmental Pollution	Energy - The Changing Climate	60% reduction in national CO2 emissions from fossil fuel combustion relative to the 1998 level in 2050
UK	Department of Trade and Industry	Energy White Paper	60% reduction in national CO2 emissions from current level (or more precisely from 58% from 1997 levels). This would lead to 2050 emissions of 64 million tonnes of carbon (MtC)
UK	Tyndall Centre	Decarbonising the UK	A true 60% reduction in national CO2 emissions by 2050
France	French Interministerial Task Force on Climate Change	Reducing CO2 emissions fourfold in France by 2050	75% reduction in national GHGs emissions relative to the 1998 level in 2050
Germany	Deustcher Bundestag	Enquete Commission on Sustainable Energy Supply	40% reduction in GHG emissions in the industrialised nations (i.e. also in Germany) by 2020, 50% by 2030 and 80% by 2050, relative to 1990
The Netherlands	National Institute for Public Health and the Environment et al.	COOL project	50-80% reduction in national GHG emissions by 2050 relative to 1990 level

Table 1.3: Europe – Projects Long Term (Anon 2008)

In 2000, the Royal Commission on Environmental Pollution produced its 22nd report Energy: the Changing Climate where Britain's energy system was examined in order to understand which changes were needed to reduce the country's GHG emissions by 60% by 2050 as suggested in the first IPCC assessment report. (Boyle *et al.* 2004) The Royal Commission designed four scenarios for 2050 and in all, the overall fossil fuel consumption is reduced in order to achieve the target of 60% CO_2 reduction by 2050. The Governments' 2003 Energy White Paper also defined a 60% CO_2 emissions reduction target by 2050. (HM Government 2007)

Focusing on the residential sector, in the UK, this sector is responsible for 30% of the total energy demand being a potential sector to address policies on energy efficiency and carbon emissions reductions. (Boardman *et al.* 2005) The update on the Buildings Regulations Approved Document Part L also takes into account the 60% of carbon emissions by 2050 in the residential sector by setting a group of requirements such as:

- Limiting heat losses and gains trough the building fabric;
- Space heating and domestic hot water (DHW) systems which are more energy efficient;
- Lighting energy efficient systems;
- Limit exposure to solar overheating;
- Provide sufficient information so that the buildings can be operated and maintained in such a manner as to use no more energy than reasonable;
- Air conditioned and mechanical ventilation installed, so that no more energy needs are used than the reasonable. (CIBSE 2004)

However, there is also the need to understand what exactly the new intended measures and policies will implicate in reality and how set targets are possible to be achieved. In 2005, the project '40% House' was presented, which investigates how the residential sector in the UK is able to reduce CO_2 emissions by 60%, by 2050, by delivering energy savings and efficiency measures in a feasibly designed scenario. To aim a 60% reduction there has to be a large improvement in the existing housing stock where houses have to incorporate high performance windows, to be air tight, insulated external walls and include micro generation. In the chosen scenario two thirds of the reduction is derived on energy efficiency and one third on Low or Zero Carbon (LZC) technologies. This project is an exercise of how it could be possible to achieve the 60% reduction target, however it is not the only way. (Boardman *et al.* 2005)

Even though some countries are doing more and setting more aggressive targets to achieve a greater amount of CO_2 reductions there are others that do not consider yet a long term analysis when projecting and implementing new regulations. An example of this is Portugal that to comply with the EU Directives designed a number of regulations to be implemented for the first commitment period of the Kyoto Protocol and none of them consider a longer target then 2015.

1.3 PORTUGAL ADDRESSING CLIMATE CHANGE

Portugal's total GHG emissions in 2006 were around 41% above 1990 levels and according to what agreed in the Kyoto Protocol and the European Union Burden Sharing Agreement, Portugal is committed to increase greenhouse gases (GHG) emissions by 27% by 2008 – 2012, relative to 1990 (see Table 1.2). Portugal must not exceed, during the assigned period, its Assigned Amount (AA) of 381 937 527 t CO_2e. (Ferreira *et al.* 2008, pg 4)

1.3.1 National Context

Portugal, mainland, is located between the latitudes of 37ºN and 42ºN and the longitude of 9.5ºW and 6.5ºW, an area of 89 045.1 km² in the Southwest corner of Europe (more or less 1450 km of coastline and 1200 km boarder with Spain). In the mainland, the weather conditions are influenced by the latitude, topographic relief, the Atlantic Ocean and its continentality. (IE 2006)

The Portuguese climate is characterised as Mediterranean and can be distinguished by the overlapping of the warm and dry season. These characteristics vary throughout the country depending on the distance to the Atlantic Ocean which controls temperatures and 'supply' the humidity that is then carried by western winds. (QUERCUS 2008) Throughout the year mean temperatures vary regularly, presenting their maximum values in August (about 32ºc to 34ºc) and minimums in January (2ºC in the interior and 12ºC in the coastline). The mean temperature has been rising in all Portugal's regions around 0,15º per decade since the 1970's. And analysis of temperatures indices indicates that the mean temperature rise is accompanied by an alteration in the frequency of very hot days and a decrease in the frequency of very cold ones. (IE 2006) Average annual sunlight hours record the lowest values of incidence, 1600 to 2200 hours in the Northwest of the mainland (highlands and in the Alto Minho) and, the highest values between 2600 and 3300 hours in the Southern Coast (Eastern Alentejo and Lisbon region).

Between 1990 and 2004, *"primary energy consumption grew at an annual rate of about 3%"*, registering a per capita consumption of 2,51 toe in 2004 compared with 1,78 toe in 1990. (IE 2006, pg14) Between 1990 and 2004 the increase of final energy consumption was significant, 2,5% per year. This is mainly due to the increase in the consumption of crude oil products (oil 1,7%; natural gas 24%), electricity (4,3% a year) and Transport and Services sub-sectors. The Residential and Services sub-sectors represented, in 2004, 29% of the final energy consumption. (IE 2006)

According to the Annual European Community greenhouse gas inventory 1990-2006, the total portuguese GHG emissions is estimated in 83,2 Mt CO2e without Land Use, Land Use Change and Forestry (LULUCF). Since 1990, Portugal increased emissions by approximately 40,7% (about 2,5% per annum). (EU 2008) However, Portugal, during the first commitment period is limited to the emission of +27% compared to 1990 levels.

In 2006, the principal source of GHG emissions was the energy sector. The emissions of CO_2, due, mainly, to fossil fuel combustion in energy related activities (IPCC categories 1) represented 77,5% (expressed as global warming potential (GWP) weighted emissions) of the total GHGs emissions, characterizing the energy sector as the main culprit for the large amounts of CO_2 emissions. During the period 1990-2006 the primary energy consumption produced from fossil fuel combustion represented about 84% whilst the remaining 16% are from renewable energy. (Ferreira *et al.* 2008)

Portugal: GHG emissions

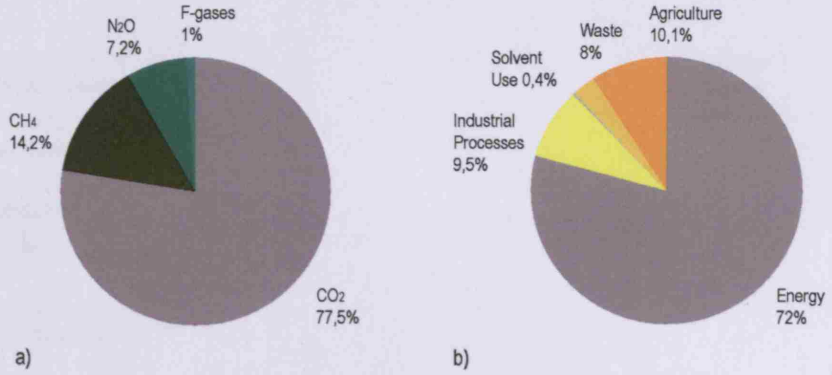


Figure 1.4: a) Share of different anthropogenic GHGs in total emissions in 2006 in terms of CO_2e; b) Share of different sectors in total anthropogenic GHG emissions in 2006 in terms of CO_2e (Energy include Energy Industries 26,8%, Manufact. Industries and Construction 12%, Transport 24,2%, Other Sectors 7,2%, Fugitive 1,8%) (Ferreira *et al.* 2008)

In order to comply with the Kyoto Protocol targets and European Union intentions and targets, Portugal had to create a number of policies and measures to help achieve what they had committed to.

1.3.2 National Policies and Measures

In 1994, Portugal ratified the UNFCCC, in 1998 signed the Kyoto Protocol and in 2002 ratified it. During the first commitment period Portugal must not exceed its Assigned Amount (AA) of 381 937 527 t CO_2e. (Ferreira *et al.* 2008, pg4)The main strategic instrument to lead Portugal on achieving the committed targets is the National Climate Change Programme (PNAC), designed by the Climate Change Commission and approved by the Council of Ministers in 2004, the Monitoring and Assessment Programme of PNAC (PNACm), the participation in the EU-ETS with the National Allocation Plan (PNALE) and the Portuguese Carbon Fund. (PNAC 2008)

PNAC creates a national strategy plan to enable Portugal to achieve the Kyoto Protocol targets. It attempts to quantify the necessary effort on mitigating emissions to accomplish the agreement by Portugal of the Kyoto Protocol, identifies responsibilities by sector (transports, energy, fishing, industry, agriculture), presents a group of policies, measures (measures for a reference scenario and additional measures) and the tools that will allow for the reduction of emissions. For Portugal to achieve the established targets – a limited increase of 27% on GHG emissions from 2008 to 2012 – it has to reduce 16 Mt - 21 Mt of CO_2e (mega tonnes equivalent carbon dioxide). However the reference scenario's measures and the additional measures will not be enough to achieve the targets – 27% GHG emissions, for a 1,7 Mt to 5,6 Mt of CO_2e reduction is still needed. Therefore it is necessary to develop national mechanisms to incorporate some of the flexible mechanisms suggested by the Kyoto Protocol - Emissions Trading, Clean Development Mechanism (CDM) and Joint Implementation (JI).
The energy consumption in the residential and services sector has the highest increase on GHG, it is predicted that in 2010 emissions in this sector will rise 126% to 135% compared to 1990. Where, the most significant increase is noticed in the transport sector in volumetric terms, superior to 100% in any scenario. (PNAC 2004)

Portugal GHG Emissions Evolution per Sector

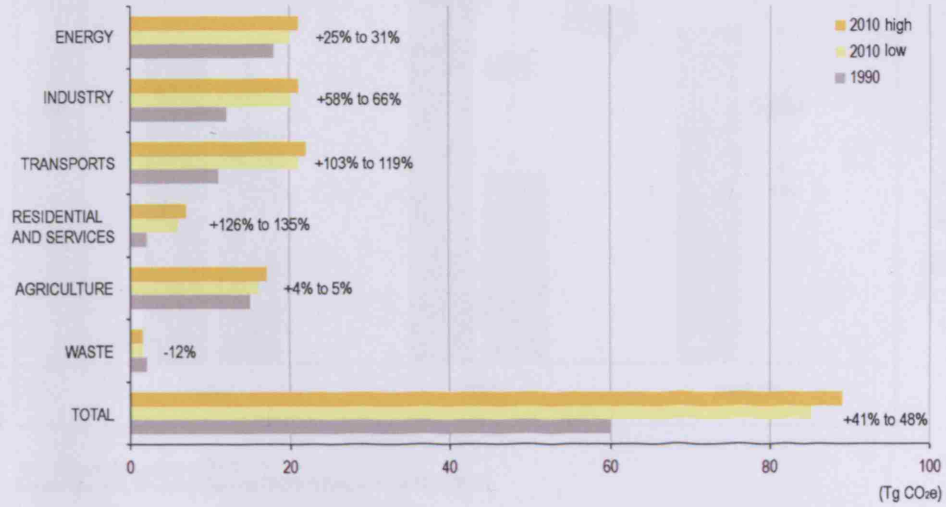


Figure 1.5: Portugal GHG Emissions Evolution per Sector (PNAC 2004)

The PNAC had already suffered two revisions in order to update base data and adapt or add new measures. The last revision was led in the beginning of 2008. At this moment, the Attributed Amount (AA) for the period of 2008 – 2012 is fixed in 381 937 527 t of CO_2e an average value of 76 367 505 t CO_2e*/year.* (PNAC 2008)

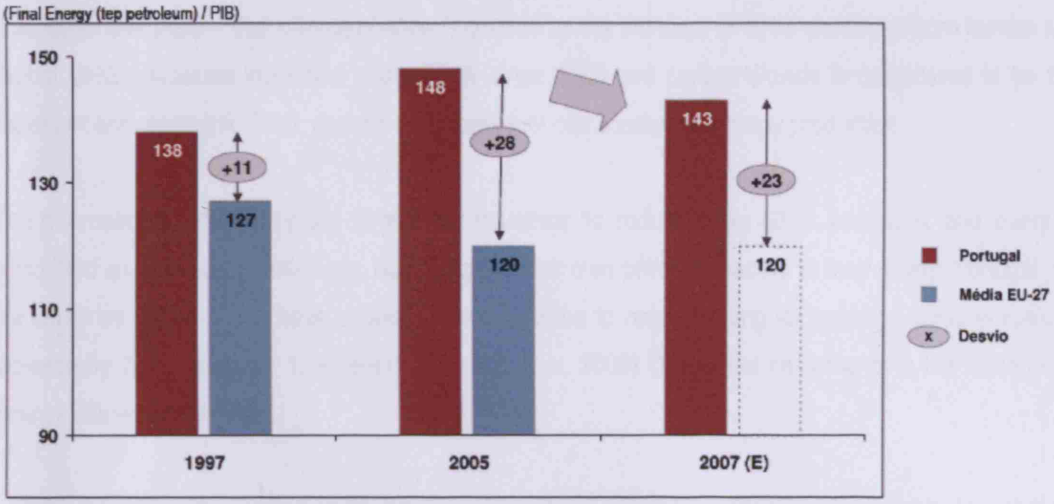
In addition to PNAC and to address the European Directive nº 2006/32/CE which establishes an obligation of all Member States to design and implement an action plan for energy efficiency with the target of 1% savings on energy each year until 2016 based on final energy consumption levels in 2001- 2005 (approximately 18 347 tep), Portugal created the National Action Plan for Energy Efficiency (PNAEE). (PNAEE 2008)

PNAEE was approved in May 2008, and incorporates a group of programmes and measures in four areas: Transports, Residential and Services, Industry and State; considered fundamental for Portugal to be able to achieve the targets set by the European directive until 2015.[1]

The residential sector registered a growth rate of 2,8%, since 1995. In 1997, in Portugal, the energy intensity was of 138 tep per millionEuros of GDP, meaning that to produce a million Euros of GDP it was necessary 11 tep petroleum, more than the European average, 127 tep per million of GDP. Energy Intensity rose until 2005 to 148 tep an opposite trend of the European tendency, 120 tep/million GDP nevertheless, from 2005 the first reductions were registered. (PNAEE 2008)

[1] At the time of this report, it was not legislated by the government how PNAEE's measures were going to be implemented.

Portugal and European average Energy Intensity



Note: PIB constant prices of 2000
Source: Eurostat; Energetic Balance (DGEG); Analysis ADENE/DGEG

Figure 1.6: Portugal and European average Energy Intensity (PNAEE 2008)

In a *business as usual* scenario, energy consumption by 2015 is predicted to be between 21,5 and 22,4 millions of thousands tep on useful energy. If the PNAEE measures are not implemented, consumption will rise in a superior rhythm than the last 5 years and the gap between Portugal's intensity and the European average will become higher.

For each specific area the plan presents a group of programmes that incorporates a vast number of energy efficiency measures. The plan's implementation will allow for energy saving of around 1792 million tep by 2015. This represents a specific electric saving by 2015 of 4777 GWh, a reduction of 7% of the national energy consumption. Without the measures specified in the plan, the consumption will rise at a higher rate than the one registered in the last 5 years. (PNAEE 2008)

The next table show the energy saving, expected, in each area.

Sector	Energy Saving (thousand tep)
TRANSPORTS	729
INDUSTRY	418
RESIDENTIAL	330
SERVICES	150
STATE	165

Table 1.4: PNAEE – Estimation of Energy Savings per Sector (PNAEE 2008)

1.4 AIMS OF THE STUDY

Scientists have proven that climate change is caused by the increase of GHG emissions from human activities. Global GHG emissions increased about 70 % since 1990 and carbon dioxide is considered to be the most important anthropogenic GHG, derived from fossil fuel combustion on energy production.

The international community set targets for countries to reduce their GHG emissions and every country committed on decreasing emissions, has designed their own policies adapted to their reality. Portugal, is one of the countries involved and have created its own policies to help reaching its target on GHG emissions, 27% increase by 2012 based on 1990 levels. (Ferreira *et al.* 2008) One of the instruments is the National Plan for Energy Efficiency (PNAEE).

In 2006, the principal source of GHG emissions in Portugal was the energy sector, responsible for about 77% of CO_2 emissions. (Ferreira *et al.* 2008) Energy consumption is rising from year to year and cities are major energy consumers in every sector.
The residential sector, energy consumption in 2004 represented 29% of the total energy consumption; it has the highest increase on GHG according to PNAEE's prediction for 2010, compared to 1990. (IE 2006) Even though new developments are planned to be sustainable as either low or zero carbon communities there is still the need to do something about the existing stock.

Considering this specific sector from a neighbourhood in Lisbon, Bairro de Alvalade, it is the aim of this study to:

- test the feasibility of the plan, of the residential sector, on an urban area;
- determine the impact of the residential measures on CO_2 emissions by 2050 in the case study area;
- determine if the residential measures will be enough to reduce CO_2 emissions by 60% in the case study area
- determine what would it take to reach 60% reduction if the plan's measures do not

The study will not consider how the measures will be implemented or how much they will cost.

In chapter 2 the plan's measures for the residential sector are described in detail.

As it is the aim of the study to test the PNAEE's measures for the residential sector the other areas that make up the plan will not be looked into.

The measures for the residential sector are divided into three groups:

1) House Refurbishment Programme
2) Energy Performance Certificate
3) Renewables

The first group entails the improvement of houses in aspects such as: efficient equipment, efficient lamps, replacement of single glazed windows, insulation of external walls and integration of heat recover units. The second group is about house certification on energy performance. And the third group considers the placement of solar panels and micro-generation.

1) House Refurbishment Programme

	DOMESTIC EQUIPMENTS SUBSTITUTION	INEFFICIENT EQUIPMENTS	HOUSING REFURBISHMENT
MEASURE DESCRIPTION / FINANCIAL INCENTIVE	Efficiency Check and Credit when substituting equipments; €100 on Class A++ equipment € 50 on Class A+ equipment Financed Programmes for switching lamps and other equipments; *Phase-out* incandescent lamps by 2015 (substituted by CFL)	Tax on inefficient lamps; Restrictions on commercialising low efficient classes equipments: Fridges Class E or inferior; Air Conditioning - CoP ≤ 2,5 Information on "Whole-life-cycle-cost"	Install: 1. Efficient Windows - install double glazed or low-e windows 2. Insulation - interior/exterior 3. Heat Recover units; Heat Pumps CoP ≥ 4
OBJECTIVE	Substitution of 1 million equipments until 2015: Fridges and Freezers **energy saving = 97,5 thousand tep** Washing Machines **energy saving = 14,7 thousand tep** Lamp substitution **energy saving = 4,5 tep**	Substitute 5 million incandescent lamps by CFL until 2015	Efficient Windows (200 thousand houses) **energy saving = 3735 tep** Insulation (100 thousand houses) **energy saving = 1987 tep** Heat Recover (200 thousand houses) **energy saving = 16 020 tep**

Table 2.1: PNAEE measures – House Refurbishment Programme (PNAEE 2008)

1.1) Domestic Equipment Substitution

The aim of this measure is to increase the substitution of old and inefficient equipment for newer ones with lower energy consumption. This measure of **equipment substitution** is directioned to existing buildings and it aims to reach around one fifth of the existing houses by 2015. (PNAEE 2008)

It is estimated that classic incandescent lamps represent about 77% of lighting consumption where, nowadays, there are more efficient and superior 'whole-life-cycle' lamps. The **substitution of incandescent lamps** for CFL or equivalent ones, is thought to have a strong impact on improving energy efficiency as illumination is responsible for 14% of the national electricity consumption, equivalent to a 6,4 TWh/y consumption. In the residential sector it represents 12% of the electricity consumption, 1,5 TWh/year. The aim is to substitute 22.6 million incandescent lamps. (PNAEE 2008)

1.2) Inefficient Equipment

The idea of this measure is to penalize the use of inefficient lamps, equipment, compensate the use of efficient ones and stimulate the fulfilment of national CO2 reduction targets. Restrictive norms for the production and commercialization of inefficient equipments will also be considered. (PNAEE 2008)

1.3) Housing Refurbishment

These group measures focus on the heat losses and gains through the building envelope and heating systems. The building envelope is responsible for most of the heat losses and gains throughout the year, responsible for the undesired air infiltration and for the increase or decrease of buildings energy load. **Windows** are the most vulnerable element in the building envelope and are responsible for a large portion of energy consumption due to heat losses in winter and/or heat gains in summer. It was estimated that 25 to 30% of heating needs are due to heat losses from inefficient windows. More efficient windows would reduce uncontrolled air infiltration, increase solar gains in winter and protect from solar gains in summer.

The PNAEE aims to substitute windows in about 20 000 houses per year until 2015 which represents around **0,37%** of the existing houses, 5 369 636. (INE 2008) **Insulation** minimizes energy losses, when well placed, decreasing undesired air infiltration through the building envelope. Small interventions may lead to 30% energy savings avoiding additional costs to heat/cool internal spaces. The PNAEE measures aim to provide insulation to about 10 000 houses per year until 2015 which represents around **0,19%** of the existing housing stock. (PNAEE 2008)

The **heat recover units** mentioned in the plan are like closed fireplaces, where recovering 90% of heat compared to 15% of normal fireplace. The heat recover units are individual units to me placed in each room, supplied by wood pellets, produce no smoke or smells; there is no need for a chimney, only a ventilation tube of about 80mm to the exterior. The low cost of the biomass – wood pellets – makes this energy source competitive compared to conventional ones. PNAEE measures aims to install 20 000 equipments per year until 2015 in about 2 500 houses per year, which represents around **0,05%** of the existing stock.(PNAEE 2008)

2. Energy Performance Certificate

The Energy Performance Certificate aims to improve buildings energy performance. New buildings and/or big refurbishments have to achieve a minimum classification in order to get the certificate. The objective is to certify 450 000 houses until 2015, 34 000 new houses and 25 000 refurbished, per year. (PNAEE 2008)

The energy certification may reduce mean consumption by 30% to 40% in 5 areas: renewables, insulation, thermal bridging, glazing and shading. The total energy saving for this measure is estimated in 94 ktep, by 2015. (PNAEE 2008)

3. Renewables

The micro-generation of energy and decentralisation of the energy system will allow for singular or collective entities to produce low tension electricity and send it back to the national grid at a maximum of 5,75 kW. The aim of the measure is to have installed 165 MW of energy generated by renewable energy – photovoltaic, wind, hydro, biomass co-generation, until 2015. The plan considers that from the before mentioned technologies PV's and wind turbines are more developed and ready to be placed whilst biomass co-generation and batteries are considered, still, in an immature stage. There is also the objective of 1 in 15 houses to have solar collectors by 2015. (PNAEE 2008)

	MICRO-GENERATION	SOLAR THERMAL
MEASURE DESCRIPTION / FINANCIAL INCENTIVE	Simplified registration system to install micro-generation renewables up to 5 kW (solar, wind, CHP, biomass, hidric, btteries) 10 MW per year increasing 20% a year Estimation of 1 m2 per kW installed	Publicity on solar thermal panels; Monetary incentive to fix or update old equipments; Incentive for new installations by 30% beneficts in VAT; All new buildings have to install solar panels; Obligation to install 2m2 to have access to granted tariffs Specific programmes for Social Housing; Swimming Pools and Solar housing
OBJECTIVE	165 MW installed capacity; **Energy saving = 48 471 tep**	1 in each 15 buildings with solar thermal panels; **Energy saving = 58 796 tep**

Table 2.2: PNAEE measures – Renewables (PNAEE 2008)

The plan was designed to improve national energy efficiency and its targets are set as energy saving and whenever there is an improvement on energy efficiency and an increase in energy saving there is a reduction in CO_2 emissions. It is the aim of the study to determine the impact of PNAEE's measures on CO_2 emissions therefore, to test the before mentioned measures, a specific area of Lisbon was chosen, *Bairro de Alvalade*. The following chapter presents a description of Lisbon, an energy analyses and introduces the study area.

The following chapter presents a brief analysis of Lisbon's energy situation and describes the neighbourhood where PNAEE is to be tested.

Lisbon is the capital and largest Portuguese city. It is located at 38º 42' N and 9º 10' W, has about 83,84 km² and in 2006, Lisbon's population was estimated to have 509 751 inhabitants.[2] (INE 2008)
Winds are predominantly from Northwest to Northeast, humidity is within the comfort zone (40% to 70%) however, it is closer to the higher values of the range and temperatures vary throughout the year. In winter, temperatures may vary from 6ºC to 20ºC whereas in summer, from about 15ºC to around 30ºC having days with peak temperatures reaching 35ºC. (Weather Tool 2008) Climate data was taken from the thermal model software weather data base EnergyPlus Energy Simulation Software, in (.epw) format and converted to (.wea) to be analysed in SquareOne Weather Tool software. The weather file is from 2002. (EnergyPlus 2008)

Lisbon and Portugal - Inhabitants, Residential Buildings and Homes

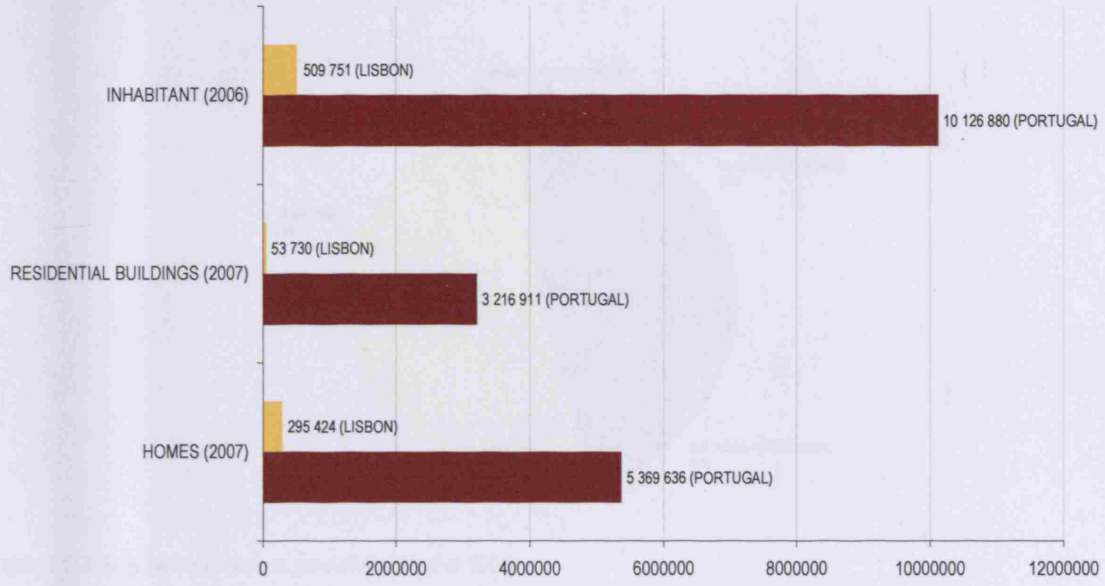


Figure 3.1: Lisbon and Portugal – Inhabitants, Residential Buildings and Homes, data related to 2006 and 2007 (INE 2008)

[2] The area referred to as Greater Lisbon has about 2 019 529 inhabitants. (INE 2008)

3.1 LISBON'S ENERGY ANALYSIS

According to the Lisbon Energy Matrix, the total annual primary energy consumption of Lisbon is about 15 000 GWh which corresponds to about 6% of mainland Portugal´s consumption.[3] 'Electricity'[4] has the highest percentage of primary energy consumption; it represents 41% of the total primary energy consumption in Lisbon.

Buildings are the main consumers of Lisbon's primary energy, representing 46% of total consumption, mostly from electricity. Transports come second with 42% and Industry last with 10%.
The Building stock is divided in two sectors, Service sector (65% consumption; 2% of the total consumption in Portugal); and Residential sector (35% consumption - 1% of the total consumption in Portugal). (Sá *et al.* 2004)
A disaggregation of the energy sector GHG emissions show that, buildings are responsible for 45% (1682841 CO_2e) of the emissions (residential 15%; services 30%), slightly higher value than transports, 43% (1580000 CO_2e).

Energy Sector Emissions per Activity

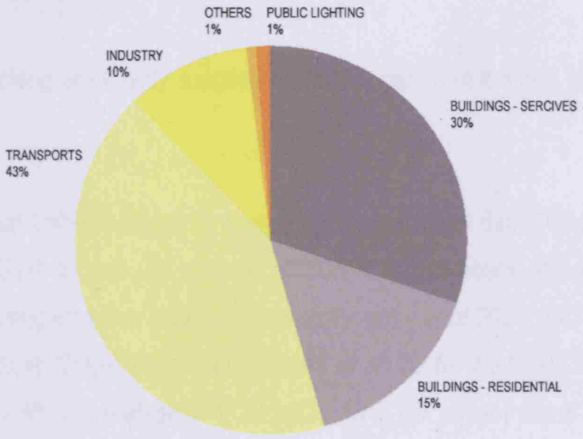


Figure 3.2: Energy Sector Emissions per Activity (Sá *et al.* 2004)

A disaggregation of the energy consumption per activity show that Domestic Hot Water (DHW) represents 24% of the consumption while energy from fridges and freezers, heating and cooking represent 18%, 17% and 16% respectively.

[3] In the Lisbon Energy Matrix the energy data for Lisbon is assumed to be the same as the district of Lisbon (2 794 226 inhabitants in 2006 (INE 2008)) due to the lack of information in a smaller scale. Energy consumption was based on specific average consumption data from 2002.
[4] 'Electricity' is addressed here as the total amount of fossil fuels necessary to generate electricity.

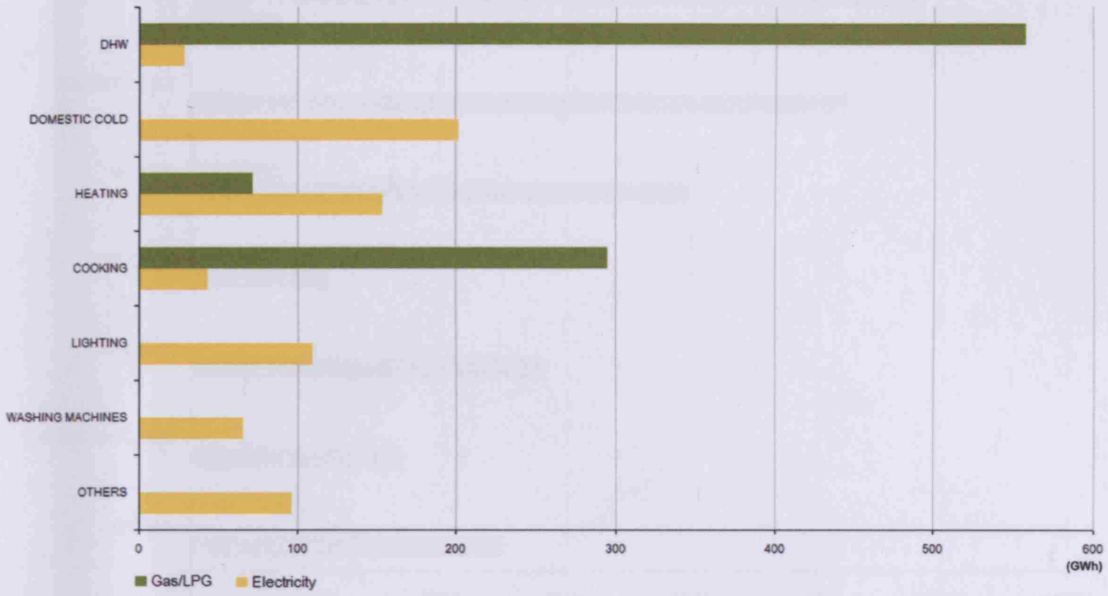


Figure 3.3: Lisbon – Delivered Energy Consumption per fuel supply (Sá *et al.* 2004)

Domestic hot water and cooking are mainly supplied by natural gas from the grid whilst all the other activities use mainly electricity.

In 2004 it was estimated that Lisbon's electricity consumption was about 695 GWh, an average of 2352 kWh per house and about 922 GWh for gas, an average of 3120 kWh per house. (Sá *et al.* 2004) Assuming the same values for 2008 and using emission factors for electricity and gas of 2008: 0,47 kg CO_2/kWh for electricity (MAOTDREI 2008) and 0,20 kg CO_2/kWh for gas (Ferreira *et al.* 2008), the total CO_2 emissions for Lisbon is about 511 050 000 kgCO_2/kWh, an average of 1729 kgCO_2/kWh per house, where 326 650 000 kg CO_2/kWh are from electricity and 184 400 000 kgCO_2/kWh from gas.

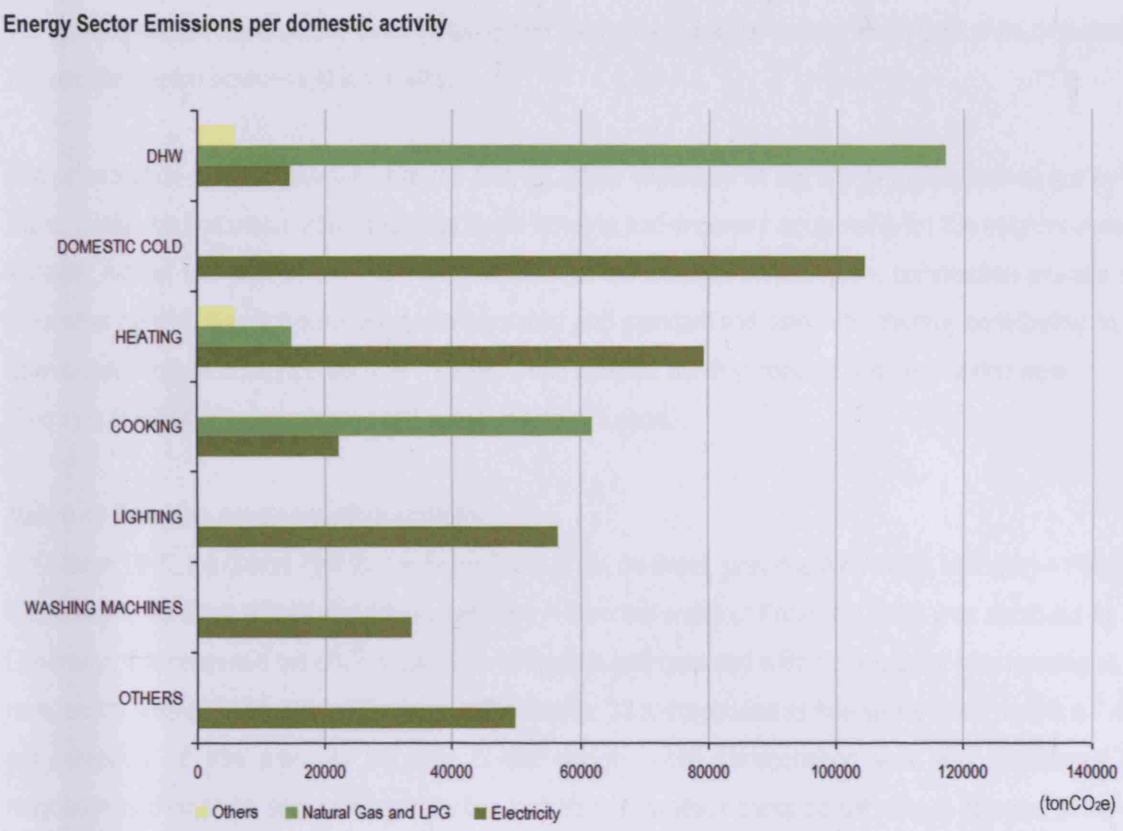


Figure 3.4: Lisbon – Energy Sector Emissions per domestic activity (Sá *et al.* 2004)

3.2 LISBON'S NEIGHBOURHOOD - *BAIRRO DE ALVALADE*

Figure 3.5: Lisbon – study area location, *Bairro de Alvalade*

The study area is located next to Lisbon's airport on the northern part of the city and is part of an urbanization plan created by the government in the 40's.

The urbanization plan for *Alvalade* was the first big urban expansion of the city of Lisbon carried out by the State. It was the first urban plan integrating social housing and important equipments for the neighbourhood – schools, market and commerce. The systematization of the different project types, construction process and innovative construction solutions using pre-fabricated and standardised elements, thereby contributing to the operational success in aspects such as – social, urban concept, building concept and engineering work.
Bairro de Alvalade is a consolidated and qualified area of Lisbon.

***Bairro de Alvalade* development description**

In October 1945, the Urban Plan for the South Zone of Av. do Brasil (previous Av. Alferes Malheiro) – *Plano de Urbanização da Zona Sul da Av. Alferes Malheiro* – from the architect Faria da Costa, was approved by the Government. It promoted the city's expansion northwards and complied with the needs for new housing at the time, a total area of 230 hectares. From the 230 hectares, 33 are proposed as free space which means a 7.4m2 per inhabitant of free area. At the time of the design public transportation was also considered, the neighbourhood could be accessed by train, bus and tram. Nowadays trams do not exist in this part of the city and have been substituted by the underground. (Costa 2005)

The urbanization plan reflected concepts, architectural and urban tendencies of the XX century: road hierarchy, neighbourhood unity, functions distribution, public use of the block interior. Every part of the plan's process was studied in detail, from the urban plan, reflecting modern tendencies, neighbourhood Atmosphere, City garden, to the architectural image, and construction systematization. (Costa 2005)

The road grid divides the area in eight cells, creating in each one a neighbourhood unit, developed from a central element – the school – surrounded by housing. All the residential buildings were planned to be, on average, 50m away from the school, and all the equipment and leisure spaces are located within walking distance from every point of the cell. (Costa 2005)

In general, there are two types of buildings, houses – semi-detached and detached houses; and three or four story apartment buildings. Houses have two floors and a small garden around them. Residential buildings have two apartments per floor and the ones in the commercial area have commerce on the ground floor. The buildings have a clean image without ornamental architectural elements creating a single and simple image. (Costa 2005)

The housing spatial studies created a new spatial organization. Wasted spaces, such as corridors, were excluded and spaces are simpler with a more rational interior organisation. It was also the aim to endow the new type of houses with good living conditions – light in every room and cross ventilation -, ending up with a rectangular plant. (Costa 2005)

Figure 3.6: Photos – study area, June 2008

The chosen neighbourhood has a diversity of buildings that is not representative of the all Lisbon. Most of Lisbon's population lives in apartment blocks whilst this neighbourhood incorporates residential buildings (apartment blocks) and houses (semidetached and detached).

The exact area chosen to test the plan's impact and also how its measures are going to be applied are presented in the next chapter.

The previous chapters have described the residential measures of PNAEE, Lisbon's energy situation and the neighbourhood where the plan is to be applied. The following chapter will analyse the plan's measures and how it will be implemented in a specific area of the neighbourhood.

The neighbourhood, as mentioned before, was divided in eight cells however, this study will only include cells III, IV, V and VI. This area belongs to S. João de Brito borough which has about 13 000 inhabitants. (S.Joao Brito 2008) The plan below shows the buildings considered in the report. The orange hatch represents the 3 and 4 story buildings whilst the yellow hatch represents the semi-detached and detached houses.
The considered buildings occupy a total plotted area of 130 056 m2 and a total floor area of for 703 308 m2.

Figure 4.1: *Bairro de Alvalade* – Base Case Scenario buildings identification

This report focuses only on the residential area and accordingly, only residential buildings are considered. The study area was constructed from about 1950 to 1956. Cell III is characterized as a commercial area with four story residential buildings with commerce on the ground floor, Cell V and VI are residential areas with three to four story residential buildings and Cell IV is characterised by semi-detached and detached houses with small gardens.

The table below shows the number of buildings, by type and orientation, which integrate the study. For the semi detached houses an average area of 180m2 was assumed, for the detached houses 300m2 and 110m2 for every apartment.

FAÇADE ORIENTATION	SEMI-DETACHED HOUSES	DETACHED HOUSES	Nª BUILDINGS (4 floors, commerce ground floor, 6 flats)	Nº BUILDINGS (4 floors, 8 flats)	Nª BUILDINGS (3 floors, 6 flats)	TOTAL BUILDINGS	TOTAL HOUSES
Southeast - Northwest	84	9	76	48	18	235	1041
Southwest - Northeast	52	15	88	137	45	337	1961
South - North	132	7	0	0	0	139	139
West - East	78	17	0	0	0	95	95
TOTAL	346	48	164	185	63	**806**	**3236**

Table 4.1: Every house type and orientation considered in the study

4.1 *Bairro de Alvalade* AND PNAEE

The case study area includes 3236 homes and the PNAEE measures are going to be applied proportionally, as demonstrated in Table 4.2.

	PORTUGAL			CASE STUDY AREA		
	TOTAL	PER YEAR	PER YEAR (%)	PER YEAR	2015	2050
1) House Refurbishment Programme						
Fridge/Freezers[1]	1 000 000	125 000	2,30%	74	592	3108
Washing Machine[1]	1 200 000	150 000	2,80%	90	720	3780
Lamps[2]	1 130 000	141250	2,60%	84	672	3528
Windows[1]	160 000	20 000	0,37%	11	88	462
Insulation[1]	80 000	10 000	0,19%	6	48	252
Heat Recover[1]	20 000	2 500	0,05%	1	8	42
2) Energy Performance Certification						
EPC	NOT CONSIDERED					
3) Renewables						
Solar Panels[1]	214 460	26 807	0,80%	25	200	1050
Renewables[3]	165 MW	20,65 MW	0,10%	0,10%	0,80%	4,20%

Notes: [1] The plan only includes the number of lamps to be substituted therefore, 20 lamps per house were estimated in order to determine how many homes would be affected by the measure. [2] The measure Energy Performance Certificate is not considered on this study. [3] For the period of 8 years, every year 20,625MW have to be installed. The total energy production of Portugal is 19 461 MW (REN 2006) therefore, 20,625 MW represent 0,1% of the national production. For this case study 0,1% of the energy has to be produced by renewables.

Table 4.2: PNAEE's measures, National and Case Study (PNAEE 2008)

4.1.1 PNAEE measures MIXTURES

Based on the above table, Table 4.2, 5 Mixtures, showed in the table below, were designed to implement the first group measures of the plan throughout the years until 2050.

MIXTURE - PNAEE measures for measures group a. House Refurbishment Programme	nº houses per year	 2050
a. Efficient domestic equipment + Efficient Lamps + Efficient Windows + Insulation + Heat Recover	1	42
b. Efficient domestic equipment + Efficient Lamps + Efficient Windows + Insulation	5	210
c. Efficient domestic equipment + Efficient Lamps + Efficient Windows	5	210
d. Efficient domestic equipment + Efficient Lamps	63	2646
e. Efficient domestic equipment	6	252

Table 4.3: Mixtures created based on PNAEE's measures

a. Efficient Equipment, Lamps, Windows, Insulation and Heat Recover

It was assumed that the MIXTURE incorporating the heat recover units, supplied by wood *pellets,* to substitute the existing heating system, supplied by electricity, would include all the other measures, efficient equipment, lamps, double glazed windows, insulated external walls

b. Efficient Equipment, Lamps, Windows and Insulation

This MIXTURE just does not include the heat recover units, this and the previous mixture cover all the number of houses that need to be insulated per year, 6 houses.

c. Efficient Equipment, Lamps and Windows

This MIXTURE, together with the previous two cover all the number of houses that need to replace single glazed windows by double ones, 11 houses per year.

d. Efficient Equipment and Lamps and e. Efficient Equipment

Both cover all the remaining number of houses that will need to have efficient appliances, a total of about 80 a year. By 2050, according to the Table 4.3, all the houses will have efficient equipment and/or lamps.

4.2 BASE CASE SCENARIO

Before the Base Case Scenario creation, a survey was conducted in the area to know if houses have been refurbished, installed insulation, placed double glazed windows, what kind of cooling and/or heating systems are being used and what was the annual energy consumption. Nearly no information about energy consumption was provided, however, it was possible to realise that most of the houses retained their original material

characteristics, with no insulation and single glazed windows. Cooling/Heating is provided by individual mobile units and supplied by electricity.

The creation of the base case scenario was based on the survey information, assumptions, refurbishment rate from PNAEE and the created Mixtures, described above.

The base case scenario has a total of 3236 houses and 806 buildings. It was assumed that in the first 15 years of its construction none of the buildings suffered any refurbishment, and from that point, a rate of 0,5% per year, (PNAEE 2008) was considered for the four Mixtures used to create the base case scenario. (PNAEE 2008) Assuming the year of 1955 as the end of construction, 1970 is the first year for any substitution or refurbishment and 2008 is the first year of the PNAEEs' implementation. The base case scenario has 613 homes with efficient equipment (washing machine, refrigerator, dish washer), 613 homes with efficient equipment and lamps, 613 homes with efficient equipment, lamps and double windows placed, 613 homes with efficient equipment, lamps, double windows and insulation in the external walls and the remaining 784 homes keep the original construction materials and inefficient appliances.

	SEMI-DETACHED HOUSES	DETACHED HOUSES	4 Story Buildings 6 apart	4 Story Buildings 8 apart	3 Story Buildings 6 apart	TOTAL HOMES
	346	48	984	1480	378	**3236**
MIXTURE TYPE	**BASE CASE SCENARIO**					
e	65	9	186	281	72	**613**
d	65	9	186	281	72	**613**
c	65	9	186	281	72	**613**
b	65	9	186	281	72	**613**
Original Houses	86	12	240	356	90	**784**

Table 4.4: Base Case Scenario

EXTERNAL WALLS	Plaster + Concrete Block Masonry + Plaster (50 cm; U-Value of 0,5 W/m2.C)
INTERNAL WALLS	Plastered blocks (20 cm)
FLOOR WET AREAS	Tiles + Concrete Slab (20 cm; U-Value of 3,5 W/m2.C))
FLOOR REST OF THE HOUSE	Wooden Flooring + Concrete Slab (20 cm; U-Value of 3,5 W/m2.C))
ROOF	Timber Structure with roofing tile *Lusa*
WINDOWS	Single glazed windows + wooden frames (U-Value of 6 W/m2.C)

Table 4.5: Original Construction Materials (Alegre 1999)

4.3 MODELLING

To measure the impact of the different Mixtures, a model of each house type was built with DesignBuilder software, version 1.5.0.076 - Building Energy and Environmental Model. DesignBuilder is an interface to the EnergyPlus Energy Simulation software, version 2.2.0.25, which generates the dynamic thermal simulation. (DesignBuilder 2008) The models were assigned to be located in Portugal using Lisbon/Portela weather file, format .epw, from 2002, taken from the EnergyPlus weather data base (EnergyPlus 2008). The weather file is from an area adjust to the case study area.
For modelling purposes, a number of key assumptions were made regarding internal loads and occupant behaviour patterns. The same internal conditions/gains were attributed to all models.

Base Model, represents the original houses.

- Occupation was assumed to be an average of 3 persons per house,
- Cooling is not considered as it is not considered in the Lisbon's Energy Matrix either,
- Heating is supplied by electricity from the grid, small mobile radiant units,
- Cooking and domestic hot water (DHW) are supplied by natural gas also from the grid,
- Instantaneous DHW, CoP 0,9, 40 l/s per person (RCCTE 2006)
- Original construction materials, infiltration rate of 0,8 ach,
- Lighting, it was assumed that all houses have incandescent lamps
- Minimum ventilation rate in every room

The base model was first simulated without any heating system to determine if the existing internal temperatures would be considered as comfortable. In winter, without heating, internal temperature are around 14ºC and in summer, without cooling, are about 28ºC. Only heating was considered, and for a couple of hours in the bedroom and living room as seen in Table 4.7. In summer, as cooling is not considered the right parameters in the model were not changed in order to reach comfortable temperatures. The model should include external blinds during the day and windows open during the night, night ventilation.

As the purpose of the study is to determine the total CO_2 emissions for this area, to understand how the plan influences its reduction and by how much until 2050, the following CO_2 emission factors for electricity, gas and wood *pellets* were considered:

- 0,47 kgCO2/kWh, electricity (MAOTDREI 2008)
- 0,20 kgCO2/kWh, gas (Ferreira *et al.* 2008)
- 0,39 kgCO2/kWh, wood (Ferreira *et al* 2008)

The next tables present the internal conditions / gains, occupancy and operation schedules set in the base model.

Internal Conditions / Gains

	Bedrooms	Bathroom	Living Room	Kitchen
Winter (ºC)[1]	20	20	20	20
Summer (ºC)[1]	25	25	25	25
Met/Clo[2]	0,9/2,5	1,2/0,25	1,1/1	1,6/1
Suggested air supply rate (l/s p)[2]	10	15	10	60
Maintained Lighting lux (Incandescent)[2]	100	150	100	150
Lighting (W/m2)[3]				
	12	12	12	12
Equipment (W/m2)[3]				
Miscellaneous	-	-	-	20
Cooking	-	-	-	20
PC/Office	-	-	5	-
TV	-	-	5	-

Note: [1] Winter and Summer temperatures were taken from portuguese regulations RCCTE (RCCTE 2006). [2] CIBSE GUIDE A Table 1.5 Recommended comfort criteria for specific applications. The model was designed with an air supply rate of 10 l/s per person for bedrooms and living room. The minimum fresh air supply per person should not be less then 5 to 8 l/s per person. [3] Lighting - CIBSE GUIDE A Table 6.6 Energy dissipation in lamps; Equipment - CIBSE GUIDE A Table 6.7 Typical heat gains fro m PCs; CIBSE GUIDE A Appendix 6.A2: Rate of heat gin from restaurant/cooking equipment (CIBSE 2006)

Table 4.6: Base Model – Internal Conditions/Gains

Occupancy /Operation Schedules

	Bedrooms	Bathroom	Living Room	Kitchen
Occupancy				
weekday	22:00 - 08:00	07:00 - 08:30	17:00 - 23:00	19:00 - 21:00
weekend	23:00 - 10:00	10:00 - 11:30	11:00 - 24:00	18:00 - 21:00
Lighting				
weekday	22:00 - 23:00	07:00 - 08:30	17:00 - 23:00 [1]	19:00 - 21:00
weekend	22:00 - 23:00	off	17:00 - 23:00 [1]	19:00 - 21:00
Equipment				
PC/Office equipment				
weekday	-	-	17:00 - 20:00	-
weekend	-	-	16:00 - 21:00	-
TV				
weekday	-	-	18:00 - 23:00	-
weekend	-	-	11:00 - 24:00	-
Miscellaneous				
	-	-	-	19:00 - 21:00
Cooking				
	-	-	-	19:30 - 21:00
Heating				
weekday	21:00 - 23:00	-	18:30 - 22:30	-
weekend	21:00 - 23:00	-	16:30 - 22:30	-
DHW				
weekday	-	07:00 - 08:30	-	19:00 - 21:00
weekend	-	10:00 - 11:30	-	19:00 - 21:00

Note: [1] Lights will be off in summer and when there is enough natural light.
Table 4.7: Base Model – Occupancy/Operation Schedules

4.3.1 MIXTURES modelling

As mentioned before, the created Mixtures were used to implement the plan in the case study area. Having the base model set, a few changes on the internal conditions/gains, construction materials and heating systems were introduced in order to simulate each Mixture in every house type and orientation.

1) House Refurbishment Programme

a. Efficient Equipment, Lamps, Windows, Insulation and Heat Recover Model
The heating system supplied by electricity was substituted by heat recover units supplied by wood pellets. The external walls were insulated with a layer of 5 cm of wool mineral changing the U-Value of this element from 0,5W/m2.C to 0,28 W/m2.C and air infiltration rate decreased from 0,8 ach to 0,5 ach. Single glazed windows were substituted by double glazed windows with a U-Value of 2,2 W/m2.C (Office of the Deputy Prime Minister 2006). Under Portuguese regulations there is no minimum or limiting U-Value that materials have to accomplish therefore, the information was taken from the UK's regulations. Incandescent lamps were substituted by CFL, 6,9W/m2 in the kitchen to 4,6 W/m2 in bedrooms and living room. This value was calculated considering the amount of lux desired for each room. The value for the miscellaneous gains decreased to 15 W/m2, for efficient equipments to be simulated.

b. Efficient Equipment, Lamps, Windows and Insulation Model
Incorporates all the previous characteristics but the heat recovers units.

c. Efficient Equipment, Lamps and Windows Model
Incorporates all the previous characteristics but the insulated external walls.

d. Efficient Equipment and Lamps Model
Incorporates all the previous characteristics but the double glazed windows.

e. Efficient Equipment Model
Incorporates all the previous characteristics but the CFL lamps.

3) Renewables
RETScreen International Energy Model was used in the solar hot water project. RETScreen is a Clean Energy Project Analysis Software, used to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of Renewable-energy and Energy-efficient Technologies (RETs), provided by the Canadian Minister of Natural Resources. To calculate average daily solar radiation for Lisbon, the programme used the 'Surface Meteorology and Solar Energy Data Base – Nasa' – data for Lisbon/Portela. (RETScreen 2008)

a. Solar Panels for Domestic Hot Water

Almost all buildings are facing southwest or southeast and have sloped roof. The solar panel selected is from RETScreen list, Immosolar, model IS-PRO 2000 Tinox, also commercialised in Portugal. Each panels has an area of 1,96m2, a Fr coefficient of 0,75, Fr UL coefficient of 4,23 (W/m2)/ºC. (Immosolar 2008)

b. Micro-generation - PV

A polycrystalline panel was selected from Donauer solar systems, model KD210GH-2P with an efficiency of 16% with around 1,5m2 of area. This model is commercialised in Portugal. (Donauer 2008)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Out	Nov	Dec
Daily Solar Radiation - horizontal (kWh/m2/d)	2,4	3,31	4,72	6	6,82	7,26	7,25	6,71	5,39	3,81	2,59	2,01
Wind Speed (m/s)	3,3	3,7	4	4,2	4,2	4,5	4,7	4,7	3,9	3,6	3,4	3,5

Table 4.8: Lisbon's Daily Solar Radiation and Wind Speed (RETScreen 2008)

c. Micro-generation – Wind Turbines

There are several aspects to be considered and studied before placing an Urban Wind Turbine (UWT), such as the location of its placement, the type of UWT, wind speed, the position of the UWT, roof/building type, and energy that needs to be generated. For this case study area this type of renewable can not be considered for the following reasons:

- the building type, buildings were constructed about 50 year ago and are not prepare to support additional forces,
- it is preferable that UWT are placed on flat roofs,
- on average, wind speed should be around 5,5 m/s and as can be seen from Table 4.8, average wind speed in the case study area does not even reaches 5 m/s.

(Cace *et al* 2007)

d. Micro-generation – micro CHP

The plan mentions the implementation of micro CHP but also refers to the fact that this it is not developed enough to be implemented therefore, it also was not considered in this study. (PNAEE 2008)

4.4 PROCESS

1. Base case scenario

To create the base case scenario every house type with every Mixture was modelled in DesignBuilder and every result plotted in a calculation matrix that can be found in Appendix 2.

2. Plan's implementation – 1) House Refurbishment Programme

The created Mixtures were introduced in the base case scenario calculation matrix in two different ways, to understand if the implementation of the plan would result in a different total amount of CO_2 emissions by 2050:

Method 01 - assumed that semidetached houses and detached houses were the first ones to receive the PNAEE measures.

Method 02 - measures were introduced equally in every type of building and orientation.

In both methods, the first characteristics to be changed were in the houses that were still kept the original characteristics.

3. Plan's implementation – 3) Renewables

After the first group results, renewables were added up to the matrix. Solar and micro-generation were placed only in the residential buildings and two approaches were considered:

First approach – assumed that it would be possible in this urban context to install solar panels in 200 buildings by 2050 and that 4,20% of energy was provided by renewables, just to determine its effect on the CO_2 emissions and what targets would be achieved.

Second approach - its feasibility was tested in this specific area.

The base case scenario was first simulated to determine the assumed actual situation on CO_2 emissions and energy consumption. To the base case the plan's measures were applied until the year 2050. Results are presented in the following chapter.

This chapter presents the results for every MIXTURE impact, base case scenario and the 2050 scenario, on CO_2 emissions and energy consumption.

5.1 MIXTURE IMPACT

To create the base case scenario calculation matrix every building type and orientation were modelled. The table below shows the effect of each Mixture on CO_2 emission reduction, to the original house. Detailed information on every house can be seen in the tables in the Appendix 02.

MIXTURE	Impact on CO2 emissions (% reduction)	Impact on electricity consumption (% reduction)
e.	0,95 %	1,27 %
d.	4,80 %	6,80 %
c.	6,00 %	8,00 %
b.	18,0 %	24,6 %
a.	23,6 %	66,2 %

Table 5.1: Mixtures impact on CO_2 emissions and electricity consumption

Analysing the impact of every designed Mixture on CO_2 emissions it can be determined that major interventions have the greatest impact.
Substituting equipment and lamps decreases CO_2 emissions by about 5% and energy consumption by about 7%. The impact is low because the energy consumption related directly to equipments and lamps (d. and e.) decreases but, heating demand increases as not so much heat is released from appliances and the heating system has to compensate for it. Nevertheless, the total energy consumption is lower compared with the original house without efficient appliances.

The window replacement only reduced CO_2 emissions by 6% and electricity consumption by 8%, this means that improving the windows and the building envelope, improves the energy use by decreasing heating demand. The placement of insulation has an even greater impact on CO_2 emissions and energy consumption. With the insulation on the external walls, the air infiltration rate is lower decreasing 16%, from the previous Mixture, heating demand as not so many heat losses occur. The substitution of the heating system supply to wood *pellets* reduces electricity consumption substantially, as know heating is being supplied by another source. However, as the emission factor of wood *pellets* is still 0,39 kg CO_2/kWh, CO_2 emissions do not reduce with the same proportion as electricity consumption.

5.1.1 Buildings Energy Balance

The Mixtures were introduced in every building keeping the same internal conditions/gains, occupancy and behaviour schedule however, heating demand and energy consumption varied between buildings due to differences on heat losses/gains. The residential buildings have two facades exposed to the external conditions, whilst semi detached houses have three and detached houses four, therefore heat losses, through the building envelope, occur more in the last two examples leading to higher heating demand and more energy consumption per m2. On semi detached houses and detached houses a thicker layer of insulation should be placed to reduce heat losses.

5.2 BASE CASE SCENARIO

The base case scenario has a total electricity consumption of 12 311 694 kWh/year, an average of 3804 kWh/year per house, it has a total gas consumption of 10 744 312 kWh/year and an average of 3320 kWh/year per house, which represents a total of CO_2 emissions 7 939 942 $kgCO_2$/kWh per year, an average of 2453 $kgCO_2$/kWh per house.[5] The calculation matrix can be found in the Appendix 03.

The base case scenario emissions represent, per house, 30% more of the emissions estimated for Lisbon, consumes around 40% more electricity compared with Lisbon's estimation and consumes around the same of gas. Electricity consumption is responsible for 64% of the total CO_2 emissions in Lisbon, and in the base case is responsible for 73% of its total CO_2 emissions.

The higher energy consumption for the base case scenario, compared to Lisbon's averages, is explained by the fact that Lisbon's estimation includes a all range of building types from new to old whilst the base case scenario is constituted, on average, by 50 year old buildings.

LISBON	Total	per house
CO2 emissions (kgCO2/kWh)	511 050 000	1729
Electricity Consumption (kWh)	695 000 000	2352
Gas Consumption (kWh)	922 000 000	3120
Base Case Scenario	**Total**	**per house**
CO2 emissions (kgCO2/kWh)	7 939 942	2453
Electricity Consumption (kWh)	12 311 694	3804
Gas Consumption (kWh)	10744312	3320

Table 5.2: Base Case Scenario compared with Lisbon (Lisbon's information taken from the Lisbon Energy Matrix)

[5] Totals may not add up correctly due to rounding differences

5.3 CASE STUDY AREA

It was demonstrated that each measure from PNAEE has a positive effect in the CO_2 emissions as well as in energy saving however, the proportion of PNAEE measures are not enough to reach the 60% reductions on CO_2 emissions, by 2050 in the study area in *Bairro de Alvalade*.

The PNAEE was assumed to be applied until 2050. The next table presents the results obtained, for the first year and 2050, in both methods[6] when applied the designed Mixtures.

MIIXTURES Impact

BASE CASE SCENARIO	METHOD 01		METHOD 02	
	YEAR 1	2050	YEAR 1	2050
CO2 emissions (kgCO2/kWh)				
7 939 942	7 925 664	7 676 224	7 923 873	7 672 130
ELECTRICITY (kWh)				
12 311 694	12 275 805	11 660 322	12 259 990	11 601 133
GAS (kWh)				
10 744 312	10 744 312	10 744 312	10 744 312	10 744 312

Table 5.3: Mixtures Impact

Both methods present about the same amount of CO_2 emissions, a reduction of 3,4% from the Base Case Scenario. To the Mixtures results, the Renewables were added in the calculation matrix. By installing solar panels in 200 buildings CO_2 emissions reduce by 14% and with 4,2 % of the electricity production being provided by PV's CO_2 emissions decrease in a total of 17%. The entire calculation matrix may be found in the Appendix 03.

Base Case Scenario	
Total CO2 emissions (kgCO2/kWh)	7 939 942
Total Electricity Consumption (kWh)	12 311 694
Total Gas Consumption (kWh)	10744312
2050 MIXTURE	
CO2 emissions reduction (%)	3,40%
Electricity reduction (%)	5,77%
Gas reduction (%)	0,00%
2050 MIXTURE + Solar	
CO2 emissions reduction (%)	14,00%
Electricity reduction (%)	no reduction
Gas reduction (%)	25,30%
2050 MIXTURE + Solar + Micro Generation	
CO2 emissions reduction (%)	17,00%
Electricity reduction (%)	9,70%
Gas reduction (%)	no reduction
2050 Scenario	
Total CO2 emissions (kgCO2/kWh)	**6 569 662**
Total Electricity Consumption (kWh)	**11 113 886**
Total Gas Consumption (kWh)	**8 024 278**

Table 5.4: 2050 Scenario

[6] Method 01 - semidetached houses and detached houses were the first ones to receive the PNAEE measures; Method 02 - measures were introduced equally in every type of building and orientation

The PNAEE, designed to improve energy efficiency in the period 2008 to 2015 was tested in *Bairro de Alvalade* to determine its impact on CO_2 emissions in a long term period, 42 years. The implementation of the considered measures of the PNAEE reduces CO_2 emissions by only **17%,** by 2050, are then, not enough to reduce the CO_2 emissions by 60% in the study area.
The achieved 17% reduction on CO_2 emissions, represent a 6% reduction on electricity consumption and a 25% reduction on gas consumption.

The Mixtures have a very small effect on CO_2 emissions throughout the 42 years reducing by only 3,4 % the total of CO_2 emissions. The installation of solar panels 200 residential buildings, substituting natural gas to heat DHW, has the major impact increasing the total amount of reduction to 14%.

The substitution of energy supply to heat DHW from gas to renewable and electricity from the grid to micro-generation has a major effect on the overall CO_2 emission reduction compared to the Mixtures themselves. A higher percentage rate for the renewable group should be considered, reinforced by the fact that energy consumption is increasing and the energy sector is responsible for 77,5% of the CO_2 emission. (Ferreira *et al.* 2008)

5.3.1 Is it possible to install Renewables in the study area?

All residential buildings have sloped roofs with a free area of 90m2, southwest or southeast orientated making it the best orientation to install solar panels and PV's.

a. Solar Panels
To test the installation of solar panels a four story building with eight apartments was chosen. Considering a natural gas consumption of about 24 000 kWh/year to heat DHW of the all building it would be necessary to install 12 solar panels, that would occupy an area of 24 m2. For this calculation RETScreen software was used the with the climate file for Lisbon/Portela and the model specified before from Immosolar.

b. Photovoltaics
Considering the same building for the PV's study with an annual electricity consumption of about 27 000 kWh/year, if 4,20% of the energy was provided by PV's it would represent 1134 kWh/year. To generate it, as demonstrated in the table below, a total area of 4m2 area is needed. With a roof free area of 90m2, even if solar collectors are installed in the same building, there will be enough roof area for both systems.

	Daily solar Radiation	Days per month		Efficiency 16%		
	kwh/m2/d	#days	kwh/m2/month	kwh/m2/month	m2 PV	Total kWh
jan	2,4	31	74	11,904	4	47,616
feb	3,31	28	93	14,8288	4	59,3152
mar	4,72	31	146	23,4112	4	93,6448
apr	6	30	180	28,8	4	115,2
may	6,82	31	211	33,8272	4	135,3088
jun	7,26	30	218	34,848	4	139,392
jul	7,25	31	225	35,96	4	143,84
aug	6,71	31	208	33,2816	4	133,1264
sep	5,39	30	162	25,872	4	103,488
oct	3,81	31	118	18,8976	4	75,5904
nov	2,59	30	78	12,432	4	49,728
dec	2,01	31	62	9,9696	4	39,8784
TOTAL						1136,128

Table 5.5: PV's calculation for 4,2% energy production for a 4 story residential building

As demonstrated it would be possible to install solar panels and PV's at the plan's rates.

It is though, important to refer that the incorporation of solar panels and PV's are possible in the case study area due to the building's characteristics, with sloped roof and a free area of about 90m2. In several areas of the city, buildings have flat roofs and most of them are occupied with service infrastructures making it impossible to install anything in there.

The plan has a positive effect on CO_2 emissions and energy consumption. However, if applied until 2050 CO_2 reductions achieve only 17%, electricity consumption 9,7% and gas 25,3%. In a scenario where Portugal needs to reduce its GHG emissions from 41% to 27% above the 1990 levels to comply with the committed under the Kyoto Protocol, the results obtained here are too low.

6.1 HOW TO REACH A 60% CO2 EMISSION REDUCTION?

CO_2 emissions are directly related to energy consumption and therefore any attempt to reduce said emissions, in the residential sector, must rely on the following three factors:

1. Improving the energy efficiency of appliances in our homes;
2. Improving building envelopes to reduce heat loss/gain;
3. Consuming energy produced as efficiently and cleanly as possible.

The PNAEE incorporates all these aspects, unfortunately however, the level of implementation set out is insufficient to achieve the desired 60% reduction by 2050. Even though the plan was only designed to cover an eight year period, if more ambitious measures and long term scenarios are not considered from the outset, then it will be very difficult and indeed perhaps impossible to achieve long term targets.
To determine what it would take to achieve a 60% reduction, new proportions of each mixture were tested and it quickly became apparent that a more extreme approach was required.

60% Scenario

The scenario proposed by this paper to reach the 60% reduction consists of:

- all the houses being equipped with efficient equipments and lamps,
- all the houses having double glazed windows
- all external walls being insulated
- substituting the heating supply system by a more 'clean' source, gas was considered
- all houses have to have solar panels installed and,
- provide 45% of energy consumption through by micro-generation,

This is one of many possible scenarios to attempt to reach the 60% CO_2 emissions reduction in the study area,

SCENARIO 60% REDUCTION

Base Case Scenario	
Total CO2 emissions (kgCO2/kWh)	7 939 942
2050 – all MIXTURE (gas for heating)	
CO2 emissions reduction (%)	40,00%
2050 - all MIXTURE (gas for heating) + all with Solar panels	
CO2 emissions reduction (%)	42,00%
2050 - all MIXTURE (gas for heating) + all with Solar panels + 45% micro generation	
CO2 emissions reduction (%)	60,00%
2050 Scenario	
Total CO2 emissions (kgCO2/kWh)	**3 171 864**

Table 6.1: 60% Scenario

Feasibility of solar panels and PV's in the 60% Scenario

Residential buildings have a free roof area of approximately 90m2, detached houses of 30m2 and semidetached houses of around 20m2, orientated southwest to southeast. For residential buildings 24m2 of the roof space would be occupied by solar panels and if about 45% of the electricity was to be generated by PV's, around 17m2 more would be needed, For semi detached and detached houses about 4m2 of the roof would be needed for solar panels and about 5m2 for the 45% energy generation.

	Daily solar Radiation	Days per month		Efficiency 16%		
	kwh/m2/d	#days	kwh/m2/month	kwh/m2/month	m2 PV	Total kWh
jan	2,4	31	74	11,904	17	202,368
feb	3,31	28	93	14,8288	17	252,0896
mar	4,72	31	146	23,4112	17	397,9904
apr	6	30	180	28,8	17	489,6
may	6,82	31	211	33,8272	17	575,0624
jun	7,26	30	218	34,848	17	592,416
jul	7,25	31	225	35,96	17	611,32
aug	6,71	31	208	33,2816	17	565,7872
sep	5,39	30	162	25,872	17	439,824
oct	3,81	31	118	18,8976	17	321,2592
nov	2,59	30	78	12,432	17	211,344
dec	2,01	31	62	9,9696	17	169,4832
TOTAL						**4828,544**

Table 6.2: PV's calculation for 45% energy production for a 4 story residential building

	Daily solar Radiation	Days per month		Efficiency 16%		
	kwh/m2/d	#days	kwh/m2/month	kwh/m2/month	m2 PV	Total kWh
jan	2,4	31	74	11,904	4,5	53,568
feb	3,31	28	93	14,8288	4,5	66,7296
mar	4,72	31	146	23,4112	4,5	105,3504
apr	6	30	180	28,8	4,5	129,6
may	6,82	31	211	33,8272	4,5	152,2224
jun	7,26	30	218	34,848	4,5	156,816
jul	7,25	31	225	35,96	4,5	161,82
aug	6,71	31	208	33,2816	4,5	149,7672
sep	5,39	30	162	25,872	4,5	116,424
oct	3,81	31	118	18,8976	4,5	85,0392
nov	2,59	30	78	12,432	4,5	55,944
dec	2,01	31	62	9,9696	4,5	44,8632
TOTAL						**1278,144**

Table 6.3: PV's calculation for 45% energy production for detached house

Since heating demand represents the highest percentage of electricity consumption, a system that is supplied by a fuel other than electricity, in this case by gas, will reduce emissions by 40%. Electricity produced by fossil fuel combustion represents the highest percentage of the total CO_2 emissions and the substitution of its production process for one relying on a 'clean' source is essential.

Other renewables besides solar

If the 60% Scenario was to be implemented throughout Lisbon, PV's and solar panels could not be used as they were in this case study area, for the buildings types and shapes are not homogenous. New systems such as the ones mentioned in the PNAEE but disregarded for being considered to be unproven, immature can and should be applied. Community Combine Heat and Power, District Heating and District Cooling are systems have already been installed in other European cities such as Helsinki and should be considered in Portuguese cities. (Helsinginergia 2008)

It is necessary to do more to decentralise energy production in urban areas than what it is currently being done, more studies are required, and further research must be conducted to viably implement a crucial strategy.

6.2 UK, '40% HOUSE SCENARIO' – PORTUGAL, 60% SCENARIO

The emission reduction targets were set in 1997, and the first commitment period for the Kyoto Protocol started this year, 2008. The new building regulations in the UK started to be designed and implemented before 2008, so that when the commitment period began most of the regulations were already in practice. Besides setting measures for this first commitment period, policies and regulations were developed concerning a longer action plan period in order to reduce CO_2 emissions by 60% by 2050.

Portugal started designing the mechanisms to tackle climate change in 2004, however, regulations and policies related to buildings were only presented this year, 2008, the first year of the commitment period, and the PNAEE's implementation is, as yet, unlegislated. Aside from the fact that policies should have been developed earlier and implemented before the first commitment period, they only consider an 8 year period ending in 2015.

Long term action plans must be considered and studied to estimate future energy consumption, the evolution of CO_2 emissions and by the extent to which society will have to change its current life style.

The '40% House' report, from 2005, analyses four scenarios and tests their possibilities on reaching a 60% reduction by 2050. The report is aware of how challenging the process will be and demonstrates the extent to which the status quo will have to change. To achieve the goals set out it is necessary that:

- All cavity walls be insulated;
- All windows be high performance;
- All houses install energy efficient appliances and lighting;

- All space and hot water heating be provided by low and zero carbon technologies (LZC) – including community CHP, micro CHP, heat pumps, biomass, PV, solar hot water heating and wind turbines.

The 60% Scenario created in this report, for a small area of Lisbon, is in many ways similar to the 40% House scenario used in the UK down to the approaches and implementation rates considered in both. Furthermore these similarities can be seen to provide further support and evidence that the current plan for Portugal will not be able to deliver necessary results and needs to be re-designed if higher goals are intended to be achieved.

Portuguese policies and regulations, in the UK's image, should have been designed and put into force before the commitment period under the Kyoto Protocol. Should also be more ambitious and designed to cover a longer period than eight years

6.3 LIMITATIONS OF THE STUDY

6.3.1 Gathering Information

This kind of study requires a significant amount of information regarding the considered buildings, such as, the construction elements of the houses, internal thermal conditions, occupancy behaviour and energy consumption. To obtain this information a survey was carried out in the area but with no success in all covered questions. In fact nearly no information about energy consumption was provided, however, it was possible to determine that most of the houses retained their original material characteristics, with no insulation and single glazed windows. Cooling/Heating is provided by individual mobile units and supplied by electricity.

In order to get an estimation of electricity and gas consumption of the area the respective distribution companies were contacted. From the gas company no answer was obtained and from the electricity company only the total for Lisbon and an estimation of what could be the electricity consumption of the area was provided. As previously mentioned regarding the Lisbon Energy Matrix, the provided information was for the entire district of Lisbon as it was not possible to obtain through official sources the information for smaller areas within Lisbon. As accurate information for energy consumption of the area was not found, much of the study going forward was mostly based on assumptions and modelling results.

To calculate the CO_2 emissions, emission factors for electricity, gas and wood were needed. The 2008 National Inventory for the UNFCCC goes into detail of what emission factor is attributed to each fossil fuel however, it does not describe the mixture for Portugal's electricity production making it difficult to use the provided data as the emission factor as it was impossible to calculate. The government paper where the electricity emission factor provides only the number without explaining how it was determined.

6.3.2 Modelling

The models and scenarios considered were simulated as close as possible to reality however, as mentioned before much of the information had to be assumed due to the lack of input data.

Due to problems with the thermal model software DesignBuilder, the three to four story residential buildings were not simulated with the adjacent buildings but as individual ones. It is known that this has an effect on the internal conditions, there will be greater heat losses in winter, heat gains in summer, and a decrease/increase on internal temperatures and increase on the heating/cooling demand. To minimise the heat loss/gain effect, an extra layer of insulation was considered in those walls, having a total U-Value of 0,1 W/m2.C.

Being the purpose of the study to test the influence of the plan in CO_2 emissions reduction and if it is enough to reduce it by 60% by 2050 it would be important to consider changeable variables such as climate and energy production emission factors. In this study the same weather file, from now until 2050, was considered, assuming that no climate change would occur. This fact could influence the energy consumption relating to heating and consequently the CO_2 emissions. If temperatures continue to rise there is a chance that in winter temperatures will increase, decreasing heating demand but on the other side in summer temperatures will rise as well and cooling might start to be needed.

Furthermore, CO_2 emissions are calculated from energy consumption, multiplying it by the emission factors. In this study, the value of 0,47 kg CO_2/kWh was used for electricity, taken from Portaria nº63/2008, (MAOTDREI 2008) a governmental paper, and the values of 0,20 kg CO_2/kWh, 0,22 kgC CO_2/kWh and 0,39 kg CO_2/kWh for natural gas, LPG and biomass respectively, taken from the portuguese National Inventory 2008 (Ferreira *et al.* 2008), for the UNFCCC. These values were assumed to be the same for the next 42 years which, will not likely hold to be true. The process of electricity generation is intended to become more efficient and more 'clean', including more and more use of renewables.

The implementation of policies before commitment periods and the realisation of studies to determine at what percentage rate existing scenarios have to change are vital for the understanding of the actual impact of those policies, regulations, measures.

Under the Kyoto Protocol, the industrialized countries that have ratified it have to reduce GHG emissions by 5% between 2008 and 2012 based on 1990 levels.

Anthropogenic GHG have been increasing mainly due to the increase of CO_2 emissions, these in turn can be closely correlated to the energy system that is responsible for 77% of the emissions. (IPCC 2007) In order to achieve the Kyoto Protocol target, most countries established a core of policies and measures to address, not only, but mainly CO_2 reduction and improvement of the energy system, from production to final use. There are some countries leading the way in this matter and implementing policies that will go further than the Kyoto Protocol's first commitment period, they aim for a reduction of CO_2 emissions in 2050 of 60%, these countries include Japan, the UK, France and Germany.

This report studies the impact, on the residential sector, of one of the policies created by the Portuguese government to help achieve the Kyoto Protocol's targets, the National Plan for Energy Efficiency (PNAEE) The PNAEE was designed for an eight year period (2008-2015), was released this year, 2008, the first year of the commitment period and includes measures for four areas: Transports, Residential and Services, Industry and State.

The aim of the study was to determine the impact of the PNAEE's measures, on the residential sector in a defined area of Lisbon, *Bairro de Alvalade*, on CO_2 emissions by 2050 and also to determine whether the plan was aggressive enough to reduce emissions by 60% by 2050.

It was found that there are a series of limitations realising a study like this. Information on energy consumption is not easily obtained, either through surveys or energy distribution companies, and information on housing refurbishment is equally sparse and difficult to obtain.

Furthermore it was found that the plan has a positive effect on CO_2 emissions and energy consumption but its implementation rates are not enough to achieve a 60% reduction by 2050. The defined area reduced its CO_2 emissions by only.17%. In order to achieve a 60% reduction, this paper developed a scenario where all houses were: insulated on the external walls, had double glazed windows, fitted with efficient equipment and lamps; heated by gas supplied system, all DHW heated by solar panels and 45% of the energy consumed generated by photovoltaic's.
In a scenario where Portugal needs to reduce its GHG emissions from 41% to 27% above the 1990 levels to comply with the commitments under the Kyoto Protocol, the results obtained solely by the PNAEE are quite simply too low.

New policies should consider long term scenarios and not just concern themselves with the short term, because the reality demands that countries reduce anthropogenic GHG emission for the foreseeable future, consequentially more efforts must be placed on outlining strong and effective measures to improve energy efficiency and reduce GHG emissions reductions.

APPENDIX 01

National Plan for Climate Change – PNAC (IE 2006)

POLICIES	GHG	EMISSION REDUCTION POTENTAIL (kt CO2e by 2010)
Energy		
MRe1. "E4, E-FER" Programme	CO2, CH4, N2O	280
MRe2. Energy Efficiency in Buildings	CO2, CH4, N2O	90
MRe3. Solar Hot Water for Portugal Programme (AQSpP)	CO2, CH4, N2O	101
MAe1. Energy Efficiency improvement in the electricity generation sector	CO2, CH4, N2O	146
MAe2. Energy Efficiency improvement in the energy supply systems, considering electricity generation from co-generation	CO2, CH4, N2O	200
MAe3. Improvement in energy efficiency from the electricity demand-side	CO2, CH4, N2O	795
MAe4. Promotion of electricity produced from renewable energy sources	CO2, CH4, N2O	855
MAe5. Introduction of natural gas in the Autonomous Regions of Madeira	CO2, CH4, N2O	5
MAr1. Realignment of the tax burden on diesel fuel for heating (residential sub-sector)	CO2, CH4, N2O	14
MAs1. Realignment of the tax burden on diesel fuel for heating (services sub-sector)	CO2, CH4, N2O	59
MAi1. Increase in tax on industrial fuels	CO2, CH4, N2O	78
MAi2. Review of the regulation on the Management of Energy Consumption (RGCE)	CO2, CH4, N2O	32
MAi3. Incentives to the substitution of fuel oil co-generation by natural gas generation	CO2, CH4, N2O	189
Transport		
MRt1. Auto-Oil Programme - Voluntary agreement with the car manufacturing associations (ACEA, JAMA, KAMA)	CO2, CH4, N2O	175
MRt2. Expansion of the Lisbon Metro (ML) - extension of the Blue line, extension of the Yellow line, Red line	CO2, CH4, N2O	15
MRt3. Construction of the South of the Tagus River Metro	CO2, CH4, N2O	13
MRt4. Construction of Oporto Metro	CO2, CH4, N2O	30
MRt5. Construction of Mondego Light Metro	CO2, CH4, N2O	NA
MRt6. Supply changes (reduction in travel time) between Lisbon-Oporto; Lisbon-Castelo Branco; Lisbon-Algarve	CO2, CH4, N2O	78
MRt7. Enlargement of the fleet of vehicles powered by natural gas of CARRIS and of the STCP	CO2, CH4, N2O	1
MRt8. Incentive Programme for the dismantling of End-of-Life Vehicles	CO2, CH4, N2O	3
MRt9. Reduction of motorway speeds	CO2, CH4, N2O	0,6
MRt10. Biofuels Directive	CO2, CH4, N2O	1243
MAt1. Reduction of Taxis' service days	CO2, CH4, N2O	4
MAt2. Enlargement of the fleet of taxi vehicles powered by natural gas	CO2, CH4, N2O	0,2
MAt3. Review of the current tax regime on private vehicles	CO2, CH4, N2O	8
MAt4. Metropolitan Authority of Lisbon Transports	CO2, CH4, N2O	245
MAt5. Metropolitan Authority of Oporto Transports	CO2, CH4, N2O	101
Agriculture		
MAt6. Incentive Programme for the dismantling of End-of-Life Vehicles (further objectives)	CO2, CH4, N2O	0,4
MAt7. Regulation on Energy Management in the Transport Sector	CO2, CH4, N2O	18
MAt8. Railway connection to Aveiro Sea Port	CO2, CH4, N2O	40

MAt9. Shipping routes	CO2, CH4, N2O	150
MAt10. Logistical Platforms	CO2, CH4, N2O	Planning
MAt11. Restructuring of supply of CP (national railway)service	CO2, CH4, N2O	44
MRg1. IPPC Directive (Integrated Preventation and Pollution Control)	-	NA
MAg1. Evaluation and promotion of carbon sequestration in agricultural soil	CO2	500
MAg2. Treatment and Energy recover of lifestock waste	CO2, CH4, N2O	429
Land Use, Land Use Change and Forestry		
MRf1. Programme for the Sustainable Development of Portuguese Forests (in the context of IIIFSP)	CO2	3743
MAf1. Promotion of carbon sink capacity of forests	CO2	800
Waste		
MRr1. Directive on Packaging and Packaging Waste	CO2, CH4, N2O	900
MRr2. Landfill Directive	CH4	363
MRr2. IPPC Directive (Integrated Prevention and Pollution Control	CO2, CH4	NA

APPENDIX 02

Results for every MIXTURE simulation in every house type and Orientation

SEMI DETACHED - South North (180m2)	original	e	d	c	b	a	gas
CO2(kg)	3667	3638	3512	3438	3132	2851	2186
CO2(kg) SOLAR	2963	2935	2809	2734	2428	2147	1552
CO2(kg) RNW	3544	3517	3396	3325	3032	2820	1454
CO2(kg) RNW/SOLAR	2841	2814	2693	2621	2328	2117	1451
Electricity (kWh/m2)	34	34	33	32	28	9	9
Electricity (kWh)	6196	6136	5868	5709	5057	1554	1554
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	3773	3773	3773	3773	3773	3773	3773
Other Fuel (kWh/m2)						19	19
Other Fuel (kWh)						3502	3502
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

DETACHED - South North (300m2)	original	e	d	c	b	a	gas
CO2(kg)	6111	6064	5854	5730	5219	4752	3643
CO2(kg) SOLAR	5407	5360	5150	5026	4516	4048	3056
CO2(kg) RNW	5907	5862	5661	5542	5053	4701	2424
CO2(kg) RNW/SOLAR	5203	5158	4957	4838	4349	3997	2888
Electricity (kWh/m2)	34	34	33	32	28	9	9
Electricity (kWh)	10326	10227	9779	9515	8429	2591	2591
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	6288	6288	6288	6288	6288	6288	6288
Other Fuel (kWh/m2)						19	19
Other Fuel (kWh)						5837	5837
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

SEMI DETACHED - West East (180m2)	original	e	d	c	b	a	gas
CO2(kg)	3656	3627	3493	3416	3123	2820	2170
CO2(kg) SOLAR	2952	2923	2789	2712	2420	2116	1534
CO2(kg) RNW	3534	3506	3378	3304	3024	2789	1454
CO2(kg) RNW/SOLAR	2830	2803	2674	2600	2320	2085	1435
Electricity (kWh/m2)	34	34	32	31	28	9	9
Electricity (kWh)	6173	6112	5826	5662	5040	1554	1554
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	3773	3773	3773	3773	3773	3773	3773
Other Fuel (kWh/m2)						19	19
Other Fuel (kWh)						3422	3422
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

DETACHED - West East (300m2)	original	e	d	c	b	a	gas
CO2(kg)	6093	6045	5821	5693	5205	4700	3616
CO2(kg) SOLAR	5389	5341	5117	4989	4502	3996	3026
CO2(kg) RNW	5890	5844	5629	5507	5040	4649	2424
CO2(kg) RNW/SOLAR	5186	5140	4926	4803	4336	3945	2861
Electricity (kWh/m2)	34	34	32	31	28	9	9
Electricity (kWh)	10288	10186	9709	9437	8400	2591	2591
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	6288	6288	6288	6288	6288	6288	6288
Other Fuel (kWh/m2)						19	19
Other Fuel (kWh)						5704	5704
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

SEMI DETACHED - Southwest Northeast (180m2)	original	e	d	c	b	a	gas
CO2(kg)	3656	3627	3493	3416	3123	2820	2170
CO2(kg) SOLAR	2952	2923	2789	2712	2420	2116	1535
CO2(kg) RNW	3534	3506	3378	3304	3024	2789	1455
CO2(kg) RNW/SOLAR	2830	2803	2674	2600	2320	2086	1435
Electricity (kWh/m2)	34	34	32	31	28	9	9
Electricity (kWh)	6173	6112	5826	5662	5040	1555	1555
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	3773	3773	3773	3773	3773	3773	3773
Other Fuel (kWh/m2)						19	19
Other Fuel (kWh)						3422	3422
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

DETACHED - Southwest Northeast (300m2)	original	e	d	c	b	a	gas
CO2(kg)	6093	6045	5821	5693	5205	4700	3616
CO2(kg) SOLAR	5389	5341	5117	4989	4502	3996	3027
CO2(kg) RNW	5890	5844	5629	5507	5040	4649	2424
CO2(kg) RNW/SOLAR	5186	5140	4926	4803	4336	3945	2861
Electricity (kWh/m2)	34	34	32	31	28	9	9
Electricity (kWh)	10288	10186	9709	9437	8400	2591	2591
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	6288	6288	6288	6288	6288	6288	6288
Other Fuel (kWh/m2)						19	19
Other Fuel (kWh)						5704	5704
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

SEMI DETACHED - Southeast Northwest (180m2)	original	e	d	c	b	a	gas
CO2(kg)	3688	3659	3523	3446	3141	2859	2190
CO2(kg) SOLAR	2984	2955	2819	2743	2437	2155	1557
CO2(kg) RNW	3565	3537	3407	3333	3041	2828	1455
CO2(kg) RNW/SOLAR	2861	2833	2703	2630	2337	2125	1455
Electricity (kWh/m2)	35	34	33	32	28	9	9
Electricity (kWh)	6241	6180	5890	5727	5077	1555	1555
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	3773	3773	3773	3773	3773	3773	3773
Other Fuel (kWh/m2)						20	20
Other Fuel (kWh)						3523	3523
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

DETACHED - Southeast Northwest (300m2)	original	e	d	c	b	a	gas
CO2(kg)	6146	6099	5871	5744	5235	4765	3650
CO2(kg) SOLAR	5443	5395	5168	5040	4531	4061	3063
CO2(kg) RNW	5941	5895	5678	5555	5068	4714	2424
CO2(kg) RNW/SOLAR	5237	5192	4974	4852	4364	4010	2895
Electricity (kWh/m2)	35	34	33	32	28	9	9
Electricity (kWh)	10402	10300	9817	9545	8462	2591	2591
Gas (kWh/m2)	21	21	21	21	21	21	21
Gas (kWh)	6288	6288	6288	6288	6288	6288	6288
Other Fuel (kWh/m2)						20	20
Other Fuel (kWh)						5871	5871
DHW (kWh/m2)	20	20	20	20	20	20	20
DHW (kWh)	3518	3518	3518	3518	3518	3518	3518

3 Story Building - Southeast Northwest	original	e	d	c	b	a	gas
CO2(kg)	14955	14814	14193	14094	12084	11332	9545
CO2(kg) SOLAR	11357	11216	10596	10496	8487	7734	5947
CO2(kg) RNW	14489	14353	13759	13664	11739	11172	9385
CO2(kg) RNW/SOLAR	10891	10756	10161	10066	8141	7574	5787
Electricity (kWh)	23612	23311	21991	21779	17504	8097	8097
Gas (kWh)	19288	19288	19288	19288	19288	19288	19288
Other Fuel (kWh)						9407	9407
DHW (kWh)	17988	17988	17988	17988	17988	17988	17988

Per Flat	original	e	d	c	b	a	gas
CO2(kg)	2493	2469	2366	2349	2014	1889	1591
CO2(kg) SOLAR	1893	1869	1766	1749	1414	1289	991
CO2(kg) RNW	2415	2392	2293	2277	1956	1251	1251
CO2(kg) RNW/SOLAR	1815	1793	1694	1678	1357	1262	1262
Electricity (kWh)	3935	3885	3665	3630	2917	1350	1350
Gas (kWh)	3215	3215	3215	3215	3215	3215	3215
Other Fuel (kWh)						1568	1568
DHW (kWh)	2998	2998	2998	2998	2998	2998	2998

3 Story Building - Southwest Northeast	original	e	d	c	b	a	gas
CO2(kg)	14762	14621	14007	13922	11968	11235	9495
CO2(kg) SOLAR	11165	11023	10409	10324	8371	7638	5897
CO2(kg) RNW	14304	14169	13581	13499	11627	11075	9335
CO2(kg) RNW/SOLAR	10707	10571	9983	9902	8030	7478	5737
Electricity (kWh)	23201	22900	21594	21414	17256	8095	8095
Gas (kWh)	19288	19288	19288	19288	19288	19288	19288
Other Fuel (kWh)						9161	9161
DHW (kWh)	17988	17988	17988	17988	17988	17988	17988

Per Flat	original	e	d	c	b	a	gas
CO2(kg)	2460	2437	2334	2320	1995	1873	1582
CO2(kg) SOLAR	1861	1837	1735	1721	1395	1273	983
CO2(kg) RNW	2384	2361	2263	2250	1938	1250	1250
CO2(kg) RNW/SOLAR	1784	1762	1664	1650	1338	1246	1246
Electricity (kWh)	3867	3817	3599	3569	2876	1349	1349
Gas (kWh)	3215	3215	3215	3215	3215	3215	3215
Other Fuel (kWh)						1527	1527
DHW (kWh)	2998	2998	2998	2998	2998	2998	2998

4 Story Building - Southeast Northwest	original	e	d	c	b	a	gas
CO2(kg)	19048	18856	18044	17877	15313	14445	12383
CO2(kg) SOLAR	14251	14059	13247	13080	10516	9648	7586
CO2(kg) RNW	18464	18280	17502	17342	14886	14232	12170
CO2(kg) RNW/SOLAR	13667	13483	12706	12545	10089	9435	7373
Electricity (kWh)	29583	29176	27448	27092	21637	10786	10786
Gas (kWh)	25717	25717	25717	25717	25717	25717	25717
Other Fuel (kWh)						10852	10852
DHW (kWh)	23984	23984	23984	23984	23984	23984	23984

Per Flat	original	e	d	c	b	a	gas
CO2(kg)	2381	2357	2256	2235	1914	2407	1548
CO2(kg) SOLAR	1781	1757	1656	1635	1315	1608	1264
CO2(kg) RNW	2308	2285	2188	2168	1861	1250	1250
CO2(kg) RNW/SOLAR	1508	1486	1388	1368	1061	980	980
Electricity (kWh)	3698	3647	3431	3387	2705	1348	1348
Gas (kWh)	3215	3215	3215	3215	3215	3215	3215
Other Fuel (kWh)						1356	1356
DHW (kWh)	3997	3997	3997	3997	3997	3997	3997

4Story Building - Southwest Northeast								Per Flat						
	original	e	d	c	b	a	gas	original	e	d	c	b	a	gas
CO2(kg)	18788	18596	17944	17646	15179	14333	12325	2349	2325	2243	2206	1897	2389	1541
CO2(kg) SOLAR	13992	13799	12974	12849	10382	9537	7529	1749	1725	1622	1606	1298	1589	1255
CO2(kg) RNW	18215	18031	17240	17121	14757	14120	12113	2277	2254	2155	2140	1845	1250	1250
CO2(kg) RNW/SOLAR	13419	13234	12443	12324	9960	9324	7316	1477	1454	1356	1341	1045	966	966
Electricity (kWh)	29032	28623	26866	26601	21352	10784	10784	3629	3578	3358	3325	2669	1348	1348
Gas (kWh)	25717	25717	25717	25717	25717	25717	25717	3215	3215	3215	3215	3215	3215	3215
Other Fuel (kWh)						10568	10568						1321	1321
DHW (kWh)	23984	23984	23984	23984	23984	23984	23984	3997	3997	3997	3997	3997	3997	3997

Calculation Matrix – Base Case Scenario Total CO_2 emissions

BASE CASE SCENARIO - CO_2 EMISSIONS

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	16	3659	58544	2	6099	12198	86	2469	212334	73	2357	172061	21	2469	51849	506986
Southwest - Northeast	10	3627	36270	3	6045	18135	100	2437	243700	208	2325	483600	51	2437	124287	905992
South - North	25	3638	90950	1	6064	6064	0	0	0	0	0	0	0	0	0	97014
West - East	14	3627	50778	3	6045	18135	0	0	0	0	0	0	0	0	0	68913
TOTAL	65	14551	**236542**	9	24253	**54532**	186	4906	**456034**	281	4682	**655661**	72	4906	**176136**	**1578905**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	16	3523	56368	2	5871	11742	86	2366	203476	73	2256	164688	21	2366	49686	485960
Southwest - Northeast	10	3493	34930	3	5821	17463	100	2334	233400	208	2243	466544	51	2334	119034	871371
South - North	25	3512	87800	1	5854	5854	0	0	0	0	0	0	0	0	0	93654
West - East	14	3493	48902	3	5821	17463	0	0	0	0	0	0	0	0	0	66365
TOTAL	65	14021	**226000**	9	23367	**52522**	186	4700	**436876**	281	4499	**631232**	72	4700	**168720**	**1517350**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	3446	55136	2	5744	11488	86	2349	202014	73	2235	163155	21	2349	49329	481122
Southwest - Northeast	10	3416	34160	3	5693	17079	100	2320	232000	208	2206	458848	51	2320	118320	860407
South - North	25	3438	85950	1	5730	5730	0	0	0	0	0	0	0	0	0	91680
West - East	14	3416	47824	3	5693	17079	0	0	0	0	0	0	0	0	0	64903
TOTAL	65	13716	**223070**	9	22860	**51376**	186	4669	**434014**	281	4441	**622003**	72	4669	**167649**	**1498112**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	16	3141	50256	2	5235	10470	86	2014	173204	73	1914	139722	21	2014	42294	415946
Southwest - Northeast	10	3123	31230	3	5205	15615	100	1995	199500	208	1897	394576	51	1995	101745	742666
South - North	25	3132	78300	1	5219	5219	0	0	0	0	0	0	0	0	0	83519
West - East	14	3123	43722	3	5205	15615	0	0	0	0	0	0	0	0	0	59337
TOTAL	65	12519	**203508**	9	20864	**46919**	186	4009	**372704**	281	3811	**534298**	72	4009	**144039**	**1301468**
	ORIGINAL															
Southeast - Northwest	20	3688	73760	1	6146	6146	112	2493	279216	92	2381	219052	24	2493	59832	638006
Southwest - Northeast	12	3656	43872	3	6093	18279	128	2460	314880	264	2349	620136	66	2460	162360	1159527
South - North	32	3667	117344	3	6111	18333	0	0	0	0	0	0	0	0	0	135677
West - East	22	3656	80432	5	6093	30465	0	0	0	0	0	0	0	0	0	110897
TOTAL	86	14667	**315408**	12	24443	**73223**	240	4953	**594096**	356	4730	**839188**	90	4953	**222192**	**2044107**
TOTAL	346	41737	**755458**	48		**174674**	984		**1422834**	1480		**2029147**	378		**542367**	**7939942**

BASE CASE SCENARIO - ELECTRICITY CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	16	6180	98880	2	10300	20600	86	3885	334110	73	3647	266231	21	3885	81585	801406
Southwest - Northeast	10	6112	61120	3	10186	30558	100	3817	381700	208	3578	744224	51	3817	194667	1412269
South - North	25	6136	153400	1	10227	10227	0	0	0	0	0	0	0	0	0	163627
West - East	14	6112	85568	3	10180	30540	0	0	0	0	0	0	0	0	0	116108
TOTAL	65	24540	**398968**	9	40893	**91925**	186	7702	**715810**	281	7225	**1010455**	72	7702	**276252**	**2493410**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	16	5890	94240	2	9817	19634	86	3665	315190	73	3431	250463	21	3665	76965	756492
Southwest - Northeast	10	5826	58260	3	9709	29127	100	3599	359900	208	3358	698464	51	3599	183549	1329300
South - North	25	5868	146700	1	9779	9779	0	0	0	0	0	0	0	0	0	156479
West - East	14	5826	81564	3	9709	29127	0	0	0	0	0	0	0	0	0	110691
TOTAL	65	23410	**380764**	9	39014	**87667**	186	7264	**675090**	281	6789	**948927**	72	7264	**260514**	**2352962**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	5727	91632	2	9545	19090	86	3630	312180	73	3387	247251	21	3630	76230	746383
Southwest - Northeast	10	5662	56620	3	9437	28311	100	3569	356900	208	3325	691600	51	3569	182019	1315450
South - North	25	5709	142725	1	9515	9515	0	0	0	0	0	0	0	0	0	152240
West - East	14	5662	79268	3	9437	28311	0	0	0	0	0	0	0	0	0	107579
TOTAL	65	22760	**370245**	9	37934	**85227**	186	7199	**669080**	281	6712	**938851**	72	7199	**258249**	**2321652**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	16	5077	81232	2	8462	16924	86	2917	250862	73	2705	197465	21	2917	61257	607740
Southwest - Northeast	10	5040	50400	3	8400	25200	100	2876	287600	208	2669	555152	51	2876	146676	1065028
South - North	25	5057	126425	1	8429	8429	0	0	0	0	0	0	0	0	0	134854
West - East	14	5040	70560	3	8400	25200	0	0	0	0	0	0	0	0	0	95760
TOTAL	65	20214	**328617**	9	33691	**75753**	186	5793	**538462**	281	5374	**752617**	72	5793	**207933**	**1903382**
	ORIGINAL															
Southeast - Northwest	20	6241	124820	1	10402	10402	112	3935	440720	92	3698	340216	24	3935	94440	1010598
Southwest - Northeast	12	6173	74076	3	10288	30864	128	3867	494976	264	3629	958056	66	3867	255222	1813194
South - North	32	6196	198272	3	10326	30978	0	0	0	0	0	0	0	0	0	229250
West - East	22	6173	135806	5	10288	51440	0	0	0	0	0	0	0	0	0	187246
TOTAL	86	24783	**532974**	12	41304	**123684**	240	7802	**935696**	356	7327	**1298272**	90	7802	**349662**	**3240288**
TOTAL	346	69537	**1260559**	48		**291362**	984		**2189968**	1480		**3061344**	378		**833847**	**12311694**

BASE CASE SCENARIO - GAS CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	16	3773	60368	2	6288	12576	86	3215	276490	73	3215	234695	21	3215	67515	651644
Southwest - Northeast	10	3773	37730	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1210779
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	65	15092	**245245**	9	25152	**56592**	186	6430	**597990**	281	6430	**903415**	72	6430	**231480**	**2034722**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	16	3773	60368	2	6288	12576	86	3215	276490	73	3215	234695	21	3215	67515	651644
Southwest - Northeast	10	3773	37730	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1210779
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	65	15092	**245245**	9	25152	**56592**	186	6430	**597990**	281	6430	**903415**	72	6430	**231480**	**2034722**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	3773	60368	2	6288	12576	86	3215	276490	73	3215	234695	21	3215	67515	651644
Southwest - Northeast	10	3773	37730	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1210779
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	65	15092	**245245**	9	25152	**56592**	186	6430	**597990**	281	6430	**903415**	72	6430	**231480**	**2034722**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	16	3773	60368	2	6288	12576	86	3215	276490	73	3215	234695	21	3215	67515	651644
Southwest - Northeast	10	3773	37730	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1210779
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	65	15092	**245245**	9	25152	**56592**	186	6430	**597990**	281	6430	**903415**	72	6430	**231480**	**2034722**
	ORIGINAL															
Southeast - Northwest	20	3773	75460	1	6288	6288	112	3215	360080	92	3215	295780	24	3215	77160	814768
Southwest - Northeast	12	3773	45276	3	6288	18864	128	3215	411520	264	3215	848760	66	3215	212190	1536610
South - North	32	3773	120736	3	6288	18864	0	0	0	0	0	0	0	0	0	139600
West - East	22	3773	83006	5	6288	31440	0	0	0	0	0	0	0	0	0	114446
TOTAL	86	15092	**324478**	12	25152	**75456**	240	6430	**771600**	356	6430	**1144540**	90	6430	**289350**	**2605424**
TOTAL	346	**45276**	**814968**	48		**188640**	984		**1967580**	1480		**2951370**	378		**752310**	**10744312**

METHOD 01 - YEAR 1 - CO_2 EMISSIONS

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	3 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	17	3659	62203	3	6099	18297	87	2469	214803	74	2357	174418	22	2469	54318	524039
Southwest - Northeast	11	3627	39897	3	6045	18135	100	2437	243700	208	2325	483600	51	2437	124287	909619
South - North	25	3638	90950	1	6064	6064	0	0	0	0	0	0	0	0	0	97014
West - East	14	3627	50778	3	6045	18135	0	0	0	0	0	0	0	0	0	68913
TOTAL	67	14551	**243828**	10	24253	**60631**	187	4906	**458503**	282	4682	**658018**	73	4906	**178605**	**1599585**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	20	3523	70460	2	5871	11742	93	2366	220038	80	2256	180480	28	2366	66248	548968
Southwest - Northeast	13	3493	45409	6	5821	34926	106	2334	247404	214	2243	480002	57	2334	133038	940779
South - North	28	3512	98336	4	5854	23416	0	0	0	0	0	0	0	0	0	121752
West - East	17	3493	59381	8	5821	46568	0	0	0	0	0	0	0	0	0	105949
TOTAL	78	14021	**273586**	20	**23367**	**116652**	199	4700	**467442**	294	4499	**660482**	85	4700	**199286**	**1717448**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	17	3446	58582	2	5744	11488	87	2349	204363	74	2235	165390	22	2349	51678	491501
Southwest - Northeast	11	3416	37576	3	5693	17079	100	2320	232000	208	2206	458848	51	2320	118320	863823
South - North	25	3438	85950	1	5730	5730	0	0	0	0	0	0	0	0	0	91680
West - East	14	3416	47824	3	5693	17079	0	0	0	0	0	0	0	0	0	64903
TOTAL	67	13716	**229932**	9	22860	**51376**	187	4669	**436363**	282	4441	**624238**	73	4669	**169998**	**1511907**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	17	3141	53397	2	5235	10470	87	2014	175218	74	1914	141636	22	2014	44308	425029
Southwest - Northeast	11	3123	34353	3	5205	15615	100	1995	199500	208	1897	394576	51	1995	101745	745789
South - North	25	3132	78300	1	5219	5219	0	0	0	0	0	0	0	0	0	83519
West - East	14	3123	43722	3	5205	15615	0	0	0	0	0	0	0	0	0	59337
TOTAL	67	12519	**209772**	9	20864	**46919**	187	4009	**374718**	282	3811	**536212**	73	4009	**146053**	**1313674**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	1	2859	2859	0	4765	0	0	1889	0	0	1806	0	0	1889	0	2859
Southwest - Northeast	0	2820	0	0	4700	0	0	1873	0	0	1792	0	0	1873	0	0
South - North	0	2851	0	0	4752	0	0	0	0	0	0	0	0	0	0	0
West - East	0	2820	0	0	4700	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	11350	**2859**	0	18917	0	0	3762	0	0	3598	0	0	3762	0	**2859**
	ORIGINAL															
Southeast - Northwest	12	3688	44256	0	6146	0	102	2493	254286	82	2381	195242	14	2493	34902	528686
Southwest - Northeast	6	3656	21936	0	6093	0	122	2460	300120	258	2349	606042	60	2460	147600	1075698
South - North	29	3667	106343	0	6111	0	0	0	0	0	0	0	0	0	0	106343
West - East	19	3656	69464	0	6093	0	0	0	0	0	0	0	0	0	0	69464
TOTAL	66	14667	**241999**	0	24443	0	224	4953	**554406**	340	4730	**801284**	74	4953	**182502**	**1780191**
TOTAL	346	41737	695599	48	69560	107550	984	13868	1387627	1480	13223	1995514	378	13868	507160	**7925664**

Calculation Matrix – METHOD 01 – Total CO_2 emissions for the first year of the plan's implementation (just MIXTURES) (semidetached and detached houses were the first ones to receive the PNAEE's measures)

Calculation Matrix – METHOD 01 – Total Electricity consumption for the first year of the plan's implementation (just MIXTURES) (semidetached and detached houses were the first ones to receive the PNAEE's measures)

METHOD 01 - YEAR 1 - ELECTRICITY CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	17	6180	105060	3	10300	30900	87	3885	337995	74	3647	269878	22	3885	85470	829303
Southwest - Northeast	11	6112	67232	3	10186	30558	100	3917	391700	208	3578	744224	51	3917	199767	1433481
South - North	25	6136	153400	1	10227	10227	0	0	0	0	0	0	0	0	0	163627
West - East	14	6112	85568	3	10186	30558	0	0	0	0	0	0	0	0	0	116126
TOTAL	67	24540	**411260**	10	40899	**102243**	187	7802	**729695**	282	7225	**1014102**	73	7802	**285237**	**2542537**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	20	5890	117800	2	9817	19634	93	3665	340845	80	3431	274480	28	3665	102620	855379
Southwest - Northeast	13	5826	75738	6	9709	58254	106	3599	381494	214	3358	718612	57	3599	205143	1439241
South - North	28	5868	164304	4	9779	39116	0	0	0	0	0	0	0	0	0	203420
West - East	17	5826	99042	8	9709	77672	0	0	0	0	0	0	0	0	0	176714
TOTAL	78	23410	**456884**	20	**39014**	**194676**	199	7264	**722339**	294	6789	**993092**	85	7264	**307763**	**2674754**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	17	5727	97359	2	9545	19090	87	3630	315810	74	3387	250638	22	3630	79860	762757
Southwest - Northeast	11	5662	62282	3	9437	28311	100	3599	359900	208	3358	698464	51	3599	183549	1332506
South - North	25	5709	142725	1	9515	9515	0	0	0	0	0	0	0	0	0	152240
West - East	14	5662	79268	3	9437	28311	0	0	0	0	0	0	0	0	0	107579
TOTAL	67	22760	**381634**	9	37934	**85227**	187	7229	**675710**	282	6745	**949102**	73	7229	**263409**	**2355082**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	17	5077	86309	2	5235	10470	87	2917	253779	74	2705	200170	22	2917	64174	614902
Southwest - Northeast	11	5040	55440	3	5205	15615	100	2876	287600	208	2669	555152	51	2876	146676	1060483
South - North	25	5057	126425	1	5219	5219	0	0	0	0	0	0	0	0	0	131644
West - East	14	5040	70560	3	5205	15615	0	0	0	0	0	0	0	0	0	86175
TOTAL	67	20214	**338734**	9	20864	**46919**	187	5793	**541379**	282	5374	**755322**	73	5793	**210850**	**1893204**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	1	1555	1555	0	2591	0	0	1350	0	0	1250	0	0	1350	0	1555
Southwest - Northeast	0	1555	0	0	2591	0	0	1350	0	0	1250	0	0	1350	0	0
South - North	0	1555	0	0	2591	0	0	0	0	0	0	0	0	0	0	0
West - East	0	1555	0	0	2591	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	6220	**1555**	0	10364	0	0	2700	0	0	2500	0	0	2700	0	**1555**
	ORIGINAL															
Southeast - Northwest	12	6241	74892	0	10402	0	102	3935	401370	82	3698	303236	14	3935	55090	834588
Southwest - Northeast	6	6173	37038	0	10288	0	122	3867	471774	258	3629	936282	60	3867	232020	1677114
South - North	29	6196	179684	0	10326	0	0	0	0	0	0	0	0	0	0	179684
West - East	19	6173	117287	0	10288	0	0	0	0	0	0	0	0	0	0	117287
TOTAL	66	24783	**408901**	0	41304	0	224	7802	**873144**	340	7327	**1239518**	74	7802	**287110**	**2808673**
TOTAL	346	69537	1158895	48	103067	149162	984	21397	2144218	1480	19926	3008942	378	21397	783197	**12275805**

METHOD 01 - YEAR 1 - GAS CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	17	3773	64141	3	6288	18864	87	3215	279705	74	3215	237910	22	3215	70730	671350
Southwest - Northeast	11	3773	41503	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1214552
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	67	15092	**252791**	10	25152	**62880**	187	6430	**601205**	282	6430	**906630**	73	6430	**234695**	**2058201**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	20	3773	75460	2	6288	12576	93	3215	298995	80	3215	257200	28	3215	90020	734251
Southwest - Northeast	13	3773	49049	6	6288	37728	106	3215	340790	214	3215	688010	57	3215	183255	1298832
South - North	28	3773	105644	4	6288	25152	0	0	0	0	0	0	0	0	0	130796
West - East	17	3773	64141	8	6288	50304	0	0	0	0	0	0	0	0	0	114445
TOTAL	78	15092	**294294**	20	**25152**	**125760**	199	6430	**639785**	294	6430	**945210**	85	6430	**273275**	**2278324**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	17	3773	64141	2	6288	12576	87	3215	279705	74	3215	237910	22	3215	70730	665062
Southwest - Northeast	11	3773	41503	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1214552
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	67	15092	**252791**	9	25152	**56592**	187	6430	**601205**	282	6430	**906630**	73	6430	**234695**	**2051913**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	17	3773	64141	2	6288	12576	87	3215	279705	74	3215	237910	22	3215	70730	665062
Southwest - Northeast	11	3773	41503	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1214552
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	67	15092	**252791**	9	25152	**56592**	187	6430	**601205**	282	6430	**906630**	73	6430	**234695**	**2051913**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	1	3773	3773	0	6288	0	0	3215	0	0	3215	0	0	3215	0	3773
Southwest - Northeast	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
South - North	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	15092	**3773**	0	25152	0	0	6430	0	0	6430	0	0	6430	0	**3773**
	ORIGINAL															
Southeast - Northwest	12	3773	45276	0	6288	0	102	3215	327930	82	3215	263630	14	3215	45010	681846
Southwest - Northeast	6	3773	22638	0	6288	0	122	3215	392230	258	3215	829470	60	3215	192900	1437238
South - North	29	3773	109417	0	6288	0	0	0	0	0	0	0	0	0	0	109417
West - East	19	3773	71687	0	6288	0	0	0	0	0	0	0	0	0	0	71687
TOTAL	66	15092	**249018**	0	25152	0	224	6430	**720160**	340	6430	**1093100**	74	6430	**237910**	**2300188**
TOTAL	346	45276	754600	48	75456	119472	984	19290	1922570	1480	19290	2906360	378	19290	707300	**10744312**

Calculation Matrix – METHOD 01 – Total Gas consumption for the first year of the plan's implementation (just MIXTURES) (semidetached and detached houses were the first ones to receive the PNAEE's measures)

METHOD 01 - 2050 - CO_2 EMISSIONS

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	3 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	0	3659	0	0	6099	0	0	2469	0	0	2357	0	0	2469	0	0
Southwest - Northeast	0	3627	0	0	6045	0	0	2437	0	0	2325	0	0	2437	0	0
South - North	0	3638	0	0	6064	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3627	0	0	6045	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	14551	0	0	24253	0	0	4906	0	0	4682	0	0	4906	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	24	3523	84552	0	5871	0	231	2366	546546	185	2256	417360	13	2366	30758	1079216
Southwest - Northeast	2	3493	6986	0	5821	0	276	2334	644184	628	2243	1408604	115	2334	268410	2328184
South - North	58	3512	203696	0	5854	0	0	0	0	0	0	0	0	0	0	203696
West - East	26	3493	90818	0	5821	0	0	0	0	0	0	0	0	0	0	90818
TOTAL	110	14021	386052	0	23367	0	507	4700	1190730	813	4499	1825964	128	4700	299168	**3701914**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	27	3446	93042	7	5744	40208	108	2349	253692	95	2235	212325	43	2349	101007	700274
Southwest - Northeast	22	3416	75152	12	5693	68316	122	2320	283040	230	2206	507380	73	2320	169360	1103248
South - North	35	3438	120330	6	5730	34380	0	0	0	0	0	0	0	0	0	154710
West - East	24	3416	81984	14	5693	79702	0	0	0	0	0	0	0	0	0	161686
TOTAL	108	13716	370508	39	22860	222606	230	4669	536732	325	4441	719705	116	4669	270367	**2119918**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	30	3141	94230	2	5235	10470	112	2014	225568	99	1914	189486	47	2014	94658	614412
Southwest - Northeast	23	3123	71829	3	5205	15615	125	1995	249375	233	1897	442001	77	1995	153615	932435
South - North	37	3132	115884	1	5219	5219	0	0	0	0	0	0	0	0	0	121103
West - East	26	3123	81198	3	5205	15615	0	0	0	0	0	0	0	0	0	96813
TOTAL	116	12519	363141	9	20864	46919	237	4009	474943	332	3811	631487	124	4009	248273	**1764763**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	3	2859	8577	0	4765	0	5	1889	9445	5	1806	9030	5	1889	9445	36497
Southwest - Northeast	5	2820	14100	0	4700	0	5	1873	9365	5	1792	8960	5	1873	9365	41790
South - North	2	2851	5702	0	4752	0	0	0	0	0	0	0	0	0	0	5702
West - East	2	2820	5640	0	4700	0	0	0	0	0	0	0	0	0	0	5640
TOTAL	12	11350	**34019**	0	18917	**0**	10	3762	**18810**	10	3598	**17990**	10	3762	**18810**	**89629**
	ORIGINAL															
Southeast - Northwest	0	3688	0	0	6146	0	0	2493	0	0	2381	0	0	2493	0	0
Southwest - Northeast	0	3656	0	0	6093	0	0	2460	0	0	2349	0	0	2460	0	0
South - North	0	3667	0	0	6111	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3656	0	0	6093	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	14667	0	0	24443	0	0	4953	0	0	4730	0	0	4953	0	**0**
TOTAL	346	**41737**	**363141**	48		**46919**	984		**474943**	1480		**631487**	378		**248273**	**7676224**

Calculation Matrix – METHOD 01 – Total CO_2 Emissions for 2050 (just MIXTURES)

(semidetached and detached houses were the first ones to receive the PNAEE's measures)

METHOD 01 - 2050 - ELECTRICITY CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	0	6180	0	0	10300	0	0	3885	0	0	3647	0	0	3885	0	0
Southwest - Northeast	0	6112	0	0	10186	0	0	3817	0	0	3578	0	0	3817	0	0
South - North	0	6136	0	0	10227	0	0	0	0	0	0	0	0	0	0	0
West - East	0	6112	0	0	10186	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	24540	0	0	40899	0	0	7702	0	0	7225	0	0	7702	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	24	5890	141360	0	9817	0	231	3665	846615	185	3431	634735	13	3665	47645	1670355
Southwest - Northeast	2	5826	11652	0	9709	0	276	3599	993324	628	3358	2108824	115	3599	413885	3527685
South - North	58	5868	340344	0	9779	0	0	0	0	0	0	0	0	0	0	340344
West - East	26	5826	151476	0	9709	0	0	0	0	0	0	0	0	0	0	151476
TOTAL	110	23410	644832	0	39014	0	507	7264	1839939	813	6789	2743559	128	7264	461530	**5689860**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	27	5727	154629	7	9545	66815	108	3630	392040	95	3387	321765	43	3630	156090	1091339
Southwest - Northeast	22	5662	124564	12	9437	113244	122	3569	435418	230	3325	764750	73	3569	260537	1698513
South - North	35	5709	199815	6	9515	57090	0	0	0	0	0	0	0	0	0	256905
West - East	24	5662	135888	14	9437	132118	0	0	0	0	0	0	0	0	0	268006
TOTAL	108	22760	614896	39	37934	369267	230	7199	827458	325	6712	1086515	116	7199	416627	**3314763**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	30	5077	152310	2	8462	16924	112	2917	326704	99	2705	267795	47	2917	137099	900832
Southwest - Northeast	23	5040	115920	3	8400	25200	125	2876	359500	233	2669	621877	77	2876	221452	1343949
South - North	37	5057	187109	1	8429	8429	0	0	0	0	0	0	0	0	0	195538
West - East	26	5040	131040	3	8400	25200	0	0	0	0	0	0	0	0	0	156240
TOTAL	116	20214	586379	9	33691	75753	237	5793	686204	332	5374	889672	124	5793	358551	**2596559**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	3	1555	4665	0	2591	0	5	1350	6750	5	1348	6740	5	1350	6750	24905
Southwest - Northeast	5	1555	7775	0	2591	0	5	1350	6750	5	1348	6740	5	1350	6750	28015
South - North	2	1555	3110	0	2591	0	0	0	0	0	0	0	0	0	0	3110
West - East	2	1555	3110	0	2591	0	0	0	0	0	0	0	0	0	0	3110
TOTAL	12	6220	**18660**	0	10364	**0**	10	2700	**13500**	10	2696	**13480**	10	2700	**13500**	**59140**
	ORIGINAL															
Southeast - Northwest	0	6241	0	0	10402	0	0	3935	0	0	3698	0	0	3935	0	0
Southwest - Northeast	0	6173	0	0	10288	0	0	3867	0	0	3629	0	0	3867	0	0
South - North	0	6196	0	0	10326	0	0	0	0	0	0	0	0	0	0	0
West - East	0	6173	0	0	10288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	24783	0	0	41304	0	0	7802	0	0	7327	0	0	7802	0	**0**
TOTAL	346	**69537**	**586379**	48		**75753**	984		**686204**	1480		**889672**	378		**358551**	**11660322**

Calculation Matrix – METHOD 01 – Total Electricity consumption for 2050 (just MIXTURES)

(semidetached and detached houses were the first ones to receive the PNAEE's measures)

METHOD 01 - 2050 - GAS CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
Southwest - Northeast	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
South - North	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	15092	0	0	25152	0	0	6430	0	0	6430	0	0	6430	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	24	3773	90552	0	6288	0	231	3215	742665	185	3215	594775	13	3215	41795	1469787
Southwest - Northeast	2	3773	7546	0	6288	0	276	3215	887340	628	3215	2019020	115	3215	369725	3283631
South - North	58	3773	218834	0	6288	0	0	0	0	0	0	0	0	0	0	218834
West - East	26	3773	98098	0	6288	0	0	0	0	0	0	0	0	0	0	98098
TOTAL	110	15092	**415030**	0	25152	**0**	507	6430	**1630005**	813	6430	**2613795**	128	6430	**411520**	**5070350**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	27	3773	101871	7	6288	44016	108	3215	347220	95	3215	305425	43	3215	138245	936777
Southwest - Northeast	22	3773	83006	12	6288	75456	122	3215	392230	230	3215	739450	73	3215	234695	1524837
South - North	35	3773	132055	6	6288	37728	0	0	0	0	0	0	0	0	0	169783
West - East	24	3773	90552	14	6288	88032	0	0	0	0	0	0	0	0	0	178584
TOTAL	108	15092	**407484**	39	25152	**245232**	230	6430	**739450**	325	6430	**1044875**	116	6430	**372940**	**2809981**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	30	3773	113190	2	6288	12576	112	3215	360080	99	3215	318285	47	3215	151105	955236
Southwest - Northeast	23	3773	86779	3	6288	18864	125	3215	401875	233	3215	749095	77	3215	247555	1504168
South - North	37	3773	139601	1	6288	6288	0	0	0	0	0	0	0	0	0	145889
West - East	26	3773	98098	3	6288	18864	0	0	0	0	0	0	0	0	0	116962
TOTAL	116	15092	**437668**	9	25152	**56592**	237	6430	**761955**	332	6430	**1067380**	124	6430	**398660**	**2722255**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	3	3773	11319	0	6288	0	5	3215	16075	5	3215	16075	5	3215	16075	59544
Southwest - Northeast	5	3773	18865	0	6288	0	5	3215	16075	5	3215	16075	5	3215	16075	67090
South - North	2	3773	7546	0	6288	0	0	0	0	0	0	0	0	0	0	7546
West - East	2	3773	7546	0	6288	0	0	0	0	0	0	0	0	0	0	7546
TOTAL	12	15092	**45276**	0	25152	**0**	10	6430	**32150**	10	6430	**32150**	10	6430	**32150**	**141726**
	ORIGINAL															
Southeast - Northwest	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
Southwest - Northeast	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
South - North	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	15092	0	0	25152	0	0	6430	0	0	6430	0	0	6430	0	**0**
TOTAL	346	45276	437668	48		56592	984		761955	1480		1067380	378		398660	**10744312**

Calculation Matrix – METHOD 01 – Total Gas consumption for 2050 (just MIXTURES)

(semidetached and detached houses were the first ones to receive the PNAEE's measures)

METHOD 02 - YEAR 1 - CO_2 EMISSIONS

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	3 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	17	3659	62203	2	6099	12198	87	2469	214803	74	2357	174418	22	2469	54318	517940
Southwest - Northeast	10	3627	36270	3	6045	18135	100	2437	243700	209	2325	485925	52	2437	126724	910754
South - North	26	3638	94588	1	6064	6064	0	0	0	0	0	0	0	0	0	100652
West - East	14	3627	50778	3	6045	18135	0	0	0	0	0	0	0	0	0	68913
TOTAL	67	14551	**243839**	9	24253	**54532**	187	4906	**458503**	283	4682	**660343**	74	4906	**181042**	**1598259**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	20	3523	70460	2	5871	11742	93	2366	220038	80	2256	180480	28	2366	66248	548968
Southwest - Northeast	14	3493	48902	3	5821	17463	108	2334	252072	216	2243	484488	59	2334	137706	940631
South - North	29	3512	101848	1	5854	5854	0	0	0	0	0	0	0	0	0	107702
West - East	17	3493	59381	5	5821	29105	0	0	0	0	0	0	0	0	0	88486
TOTAL	80	14021	**280591**	11	23367	**64164**	201	4700	**472110**	296	4499	**664968**	87	4700	**203954**	**1685787**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	3446	55136	2	5744	11488	86	2349	202014	73	2235	163155	21	2349	49329	481122
Southwest - Northeast	10	3416	34160	4	5693	22772	100	2320	232000	208	2206	458848	51	2320	118320	866100
South - North	25	3438	85950	2	5730	11460	0	0	0	0	0	0	0	0	0	97410
West - East	14	3416	47824	5	5693	28465	0	0	0	0	0	0	0	0	0	76289
TOTAL	65	13716	**223070**	13	22860	**74185**	186	4669	**434014**	281	4441	**622003**	72	4669	**167649**	**1520921**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	16	3141	50256	2	5235	10470	86	2014	173204	73	1914	139722	21	2014	42294	415946
Southwest - Northeast	10	3123	31230	5	5205	26025	100	1995	199500	208	1897	394576	51	1995	101745	753076
South - North	25	3132	78300	3	5219	15657	0	0	0	0	0	0	0	0	0	93957
West - East	14	3123	43722	4	5205	20820	0	0	0	0	0	0	0	0	0	64542
TOTAL	65	12519	**203508**	14	20864	**72972**	186	4009	**372704**	281	3811	**534298**	72	4009	**144039**	**1327521**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	0	2859	0	1	4765	4765	0	1889	0	0	1806	0	0	1889	0	4765
Southwest - Northeast	0	2820	0	0	4700	0	0	1873	0	0	1792	0	0	1873	0	0
South - North	0	2851	0	0	4752	0	0	0	0	0	0	0	0	0	0	0
West - East	0	2820	0	0	4700	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	11350	**0**	1	18917	**4765**	0	3762	0	0	3598	0	0	3762	0	**4765**
	ORIGINAL															
Southeast - Northwest	15	3688	55320	0	6146	0	104	2493	259272	84	2381	200004	16	2493	39888	554484
Southwest - Northeast	8	3656	29248	0	6093	0	120	2460	295200	255	2349	598995	57	2460	140220	1063663
South - North	27	3667	99009	0	6111	0	0	0	0	0	0	0	0	0	0	99009
West - East	19	3656	69464	0	6093	0	0	0	0	0	0	0	0	0	0	69464
TOTAL	69	14667	**253041**	0	**24443**	0	224	4953	**554472**	339	4730	**798999**	73	4953	**180108**	**1786620**
TOTAL	346	**41737**	**700388**	48		**127504**	984		1385679	1480		1993640	378		505189	**7923873**

Calculation Matrix – METHOD 02 – Total CO_2 emissions for the first year of the plan's implementation (just MIXTURES) (measures were introduced equally in every type of building and orientation)

METHOD 02 - YEAR 1 - ELECTRICITY CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	17	6180	105060	2	10300	20600	87	3885	337995	74	3647	269878	22	3885	85470	819003
Southwest - Northeast	10	6112	61120	3	10186	30558	100	3817	381700	209	3578	747802	52	3817	198484	1419664
South - North	26	6136	159536	1	10227	10227	0	0	0	0	0	0	0	0	0	169763
West - East	14	6112	85568	3	10186	30558	0	0	0	0	0	0	0	0	0	116126
TOTAL	67	24540	**411284**	9	40899	**91943**	187	7702	**719695**	283	7225	**1017680**	74	7702	**283954**	**2524556**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	20	5890	117800	2	9817	19634	93	3665	340845	80	3431	274480	28	3665	102620	855379
Southwest - Northeast	14	5816	81424	3	9709	29127	108	3599	388692	216	3358	725328	59	3599	212341	1436912
South - North	29	5868	170172	1	9779	9779	0	0	0	0	0	0	0	0	0	179951
West - East	17	5826	99042	5	9709	48545	0	0	0	0	0	0	0	0	0	147587
TOTAL	80	23400	**468438**	11	39014	**107085**	201	7264	**729537**	296	6789	**999808**	87	7264	**314961**	**2619829**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	5717	91472	2	9545	19090	86	3630	312180	73	3387	247251	21	3630	76230	746223
Southwest - Northeast	10	5662	56620	4	9437	37748	100	3569	356900	208	3325	691600	51	3569	182019	1324887
South - North	25	5709	142725	2	9515	19030	0	0	0	0	0	0	0	0	0	161755
West - East	14	5662	79268	5	9437	47185	0	0	0	0	0	0	0	0	0	126453
TOTAL	65	22750	**370085**	13	37934	**123053**	186	7199	**669080**	281	6712	**938851**	72	7199	**258249**	**2359318**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	16	5077	81232	2	8462	16924	86	2917	250862	73	2705	197465	21	2917	61257	607740
Southwest - Northeast	10	5040	50400	5	8400	42000	100	2876	287600	208	2669	555152	51	2876	146676	1081828
South - North	25	5057	126425	3	8429	25287	0	0	0	0	0	0	0	0	0	151712
West - East	14	5040	70560	4	8400	33600	0	0	0	0	0	0	0	0	0	104160
TOTAL	65	20214	**328617**	14	33691	**117811**	186	5793	**538462**	281	5374	**752617**	72	5793	**207933**	**1945440**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	0	1555	0	1	2591	2591	0	1350	0	0	1250	0	0	1350	0	2591
Southwest - Northeast	0	1555	0	0	2591	0	0	1350	0	0	1250	0	0	1350	0	0
South - North	0	1555	0	0	2591	0	0	0	0	0	0	0	0	0	0	0
West - East	0	1555	0	0	2591	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	6220	**0**	1	10364	**2591**	0	2700	0	0	2500	0	0	2700	0	**2591**
	ORIGINAL															
Southeast - Northwest	15	6241	93615	0	10402	0	104	3835	398840	84	3698	310632	16	3835	61360	864447
Southwest - Northeast	8	6173	49384	0	10288	0	120	3867	464040	255	3629	925395	57	3867	220419	1659238
South - North	27	6196	167292	0	10326	0	0	0	0	0	0	0	0	0	0	167292
West - East	19	6173	117287	0	10288	0	0	0	0	0	0	0	0	0	0	117287
TOTAL	69	24783	**427578**	0	**41304**	0	224	7702	**862880**	339	7327	**1236027**	73	7702	**281779**	**2808264**
TOTAL	346	**69537**	**1167479**	48		**209754**	984		**2121037**	1480		**3006324**	378		**773666**	**12259998**

Calculation Matrix – METHOD 02 – Total Electricity consumption for the first year of the plan's implementation (just MIXTURES) (measures were introduced equally in every type of building and orientation)

METHOD 02 - YEAR 1 - GAS CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	17	3773	64141	3	6288	18864	87	3215	279705	74	3215	237910	22	3215	70730	671350
Southwest - Northeast	11	3773	41503	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1214552
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	67	15092	**252791**	10	25152	**62880**	187	6430	**601205**	282	6430	**906630**	73	6430	**234695**	**2058201**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	20	3773	75460	2	6288	12576	93	3215	298995	80	3215	257200	28	3215	90020	734251
Southwest - Northeast	13	3773	49049	6	6288	37728	106	3215	340790	214	3215	688010	57	3215	183255	1298832
South - North	28	3773	105644	4	6288	25152	0	0	0	0	0	0	0	0	0	130796
West - East	17	3773	64141	8	6288	50304	0	0	0	0	0	0	0	0	0	114445
TOTAL	78	15092	**294294**	20	**25152**	**125760**	199	6430	**639785**	294	6430	**945210**	85	6430	**273275**	**2278324**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	17	3773	64141	2	6288	12576	87	3215	279705	74	3215	237910	22	3215	70730	665062
Southwest - Northeast	11	3773	41503	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1214552
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	67	15092	**252791**	9	25152	**56592**	187	6430	**601205**	282	6430	**906630**	73	6430	**234695**	**2051913**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	17	3773	64141	2	6288	12576	87	3215	279705	74	3215	237910	22	3215	70730	665062
Southwest - Northeast	11	3773	41503	3	6288	18864	100	3215	321500	208	3215	668720	51	3215	163965	1214552
South - North	25	3773	94325	1	6288	6288	0	0	0	0	0	0	0	0	0	100613
West - East	14	3773	52822	3	6288	18864	0	0	0	0	0	0	0	0	0	71686
TOTAL	67	15092	**252791**	9	25152	**56592**	187	6430	**601205**	282	6430	**906630**	73	6430	**234695**	**2051913**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	1	3773	3773	0	6288	0	0	3215	0	0	3215	0	0	3215	0	3773
Southwest - Northeast	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
South - North	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	15092	**3773**	0	25152	0	0	6430	0	0	6430	0	0	6430	0	**3773**
	ORIGINAL															
Southeast - Northwest	12	3773	45276	0	6288	0	102	3215	327930	82	3215	263630	14	3215	45010	681846
Southwest - Northeast	6	3773	22638	0	6288	0	122	3215	392230	258	3215	829470	60	3215	192900	1437238
South - North	29	3773	109417	0	6288	0	0	0	0	0	0	0	0	0	0	109417
West - East	19	3773	71687	0	6288	0	0	0	0	0	0	0	0	0	0	71687
TOTAL	66	15092	**249018**	0	25152	0	224	6430	**720160**	340	6430	**1093100**	74	6430	**237910**	**2300188**
TOTAL	346	45276	754600	48	75456	119472	984	19290	1922570	1480	19290	2906360	378	19290	707300	**10744312**

Calculation Matrix – METHOD 02 – Total Gas consumption for the first year of the plan's implementation (just MIXTURES) (measures were introduced equally in every type of building and orientation)

METHOD 02 - 2050 - CO_2 EMISSIONS

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	3 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	0	3659	0	0	6099	0	0	2469	0	0	2357	0	0	2469	0	0
Southwest - Northeast	0	3627	0	0	6045	0	0	2437	0	0	2325	0	0	2437	0	0
South - North	0	3638	0	0	6064	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3627	0	0	6045	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	14551	**0**	**0**	**24253**	**0**	0	**4906**	**0**	0	**4682**	**0**	0	**4906**	**0**	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	37	3523	130351	4	5871	23484	208	2366	492128	162	2256	365472	50	2366	118300	1129735
Southwest - Northeast	25	3493	87325	6	5821	34926	250	2334	583500	601	2243	1348043	111	2334	259074	2312868
South - North	54	3512	189648	2	5854	11708	0	0	0	0	0	0	0	0	0	201356
West - East	31	3493	108283	8	5821	46568	0	0	0	0	0	0	0	0	0	154851
TOTAL	147	14021	**515607**	20	23367	**116686**	458	4700	**1075628**	763	4499	**1713515**	161	4700	**377374**	**3798810**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	3446	55136	2	5744	11488	133	2349	312417	120	2235	268200	21	2349	49329	696570
Southwest - Northeast	10	3416	34160	4	5693	22772	148	2320	343360	257	2206	566942	65	2320	150800	1118034
South - North	25	3438	85950	2	5730	11460	0	0	0	0	0	0	0	0	0	97410
West - East	14	3416	47824	5	5693	28465	0	0	0	0	0	0	0	0	0	76289
TOTAL	65	13716	**223070**	13	22860	**74185**	281	4669	**655777**	377	4441	**835142**	86	4669	**200129**	**1988303**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	20	3141	62820	2	5235	10470	115	2014	231610	102	1914	195228	37	2014	74518	574646
Southwest - Northeast	10	3123	31230	5	5205	26025	130	1995	259350	238	1897	451486	94	1995	187530	955621
South - North	41	3132	128412	3	5219	15657	0	0	0	0	0	0	0	0	0	144069
West - East	22	3123	68706	4	5205	20820	0	0	0	0	0	0	0	0	0	89526
TOTAL	93	12519	**291168**	14	20864	**72972**	245	4009	**490960**	340	3811	**646714**	131	4009	**262048**	**1763862**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	11	2859	31449	1	4765	4765	0	1889	0	0	1806	0	0	1889	0	36214
Southwest - Northeast	8	2820	22560	0	4700	0	0	1873	0	0	1792	0	0	1873	0	22560
South - North	11	2851	31361	0	4752	0	0	0	0	0	0	0	0	0	0	31361
West - East	11	2820	31020	0	4700	0	0	0	0	0	0	0	0	0	0	31020
TOTAL	41	11350	**116390**	1	18917	**4765**	0	3762	0	0	3598	0	0	3762	0	**121155**
	ORIGINAL															
Southeast - Northwest	0	3688	0	0	6146	0	0	2493	0	0	2381	0	0	2493	0	0
Southwest - Northeast	0	3656	0	0	6093	0	0	2460	0	0	2349	0	0	2460	0	0
South - North	0	3667	0	0	6111	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3656	0	0	6093	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	14667	0	0	24443	0	0	4953	0	0	4730	0	0	4953	0	**0**
TOTAL	346	**41737**	**291168**	48		**72972**	984		**490960**	1480		**646714**	378		**262048**	**7672130**

Calculation Matrix – METHOD 02 – Total CO_2 Emissions 2050 (just MIXTURES)

(measures were introduced equally in every type of building and orientation)

METHOD 02 - 2050 - ELECTRICITY CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	3 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	0	6180	0	0	10300	0	0	3885	0	0	3647	0	0	3885	0	0
Southwest - Northeast	0	6112	0	0	10186	0	0	3817	0	0	3578	0	0	3817	0	0
South - North	0	6136	0	0	10227	0	0	0	0	0	0	0	0	0	0	0
West - East	0	6112	0	0	10186	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	24540	0	0	40899	0	0	7702	0	0	7225	0	0	7702	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	37	5890	217930	4	9817	39268	208	3665	762320	162	3431	555822	50	3665	183250	1758590
Southwest - Northeast	25	5826	145650	6	9709	58254	250	3599	899750	601	3358	2018158	111	3599	399489	3521301
South - North	54	5868	316872	2	9779	19558	0	0	0	0	0	0	0	0	0	336430
West - East	31	5826	180606	8	9709	77672	0	0	0	0	0	0	0	0	0	258278
TOTAL	147	23410	**861058**	20	39014	**194752**	458	7264	**1662070**	763	6789	**2573980**	161	7264	**582739**	**5874599**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	5727	91632	2	9545	19090	133	3630	482790	120	3387	406440	21	3630	76230	1076182
Southwest - Northeast	10	5662	56620	4	9437	37748	148	3569	528212	257	3325	854525	65	3569	231985	1709090
South - North	25	5709	142725	2	9515	19030	0	0	0	0	0	0	0	0	0	161755
West - East	14	5662	79268	5	9437	47185	0	0	0	0	0	0	0	0	0	126453
TOTAL	65	22760	**370245**	13	37934	**123053**	281	7199	**1011002**	377	6712	**1260965**	86	7199	**308215**	**3073480**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	20	5077	101540	2	8462	16924	115	2917	335455	102	2705	275910	37	2917	107929	837758
Southwest - Northeast	10	5040	50400	5	8400	42000	130	2876	373880	238	2669	635222	94	2876	270344	1371846
South - North	41	5057	207337	3	8429	25287	0	0	0	0	0	0	0	0	0	232624
West - East	22	5040	110880	4	8400	33600	0	0	0	0	0	0	0	0	0	144480
TOTAL	93	20214	**470157**	14	33691	**117811**	245	5793	**709335**	340	5374	**911132**	131	5793	**378273**	**2586708**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	11	1555	17105	1	2591	2591	0	1350	0	0	1348	0	0	1350	0	19696
Southwest - Northeast	8	1555	12440	0	2591	0	0	1350	0	0	1348	0	0	1350	0	12440
South - North	11	1555	17105	0	2591	0	0	0	0	0	0	0	0	0	0	17105
West - East	11	1555	17105	0	2591	0	0	0	0	0	0	0	0	0	0	17105
TOTAL	41	6220	**63755**	1	10364	**2591**	0	2700	**0**	0	2696	**0**	0	2700	**0**	**66346**
	ORIGINAL															
Southeast - Northwest	0	6241	0	0	10402	0	0	3935	0	0	3698	0	0	3935	0	0
Southwest - Northeast	0	6173	0	0	10288	0	0	3867	0	0	3629	0	0	3867	0	0
South - North	0	6196	0	0	10326	0	0	0	0	0	0	0	0	0	0	0
West - East	0	6173	0	0	10288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	24783	0	0	41304	0	0	7802	0	0	7327	0	0	7802	0	**0**
TOTAL	346	**69537**	**470157**	48		**117811**	984		**709335**	1480		**911132**	378		**378273**	**11601133**

Calculation Matrix – METHOD 02 – Total Electricity consumption 2050 (just MIXTURES)

(measures were introduced equally in every type of building and orientation)

METHOD 02 - 2050 - GAS CONSUMPTION

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kWh	Total kWh	DETACHED HOUSES	per house kWh	Total kWh	4 floors, 6 flats	per house kWh	Total kWh	4 floors, 8 flats	per house kWh	Total kWh	3 floors, 6 flats	per house kWh	Total kWh	TOTAL kWh
	EFFICIENT EQUIPMENT															
Southeast - Northwest	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
Southwest - Northeast	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
South - North	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	15092	0	0	25152	0	0	6430	0	0	6430	0	0	6430	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	37	3773	139601	4	6288	25152	208	3215	668720	162	3215	520830	50	3215	160750	1515053
Southwest - Northeast	25	3773	94325	6	6288	37728	250	3215	803750	601	3215	1932215	111	3215	356865	3224883
South - North	54	3773	203742	2	6288	12576	0	0	0	0	0	0	0	0	0	216318
West - East	31	3773	116963	8	6288	50304	0	0	0	0	0	0	0	0	0	167267
TOTAL	147	15092	**554631**	20	25152	**125760**	458	6430	**1472470**	763	6430	**2453045**	161	6430	**517615**	**5123521**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	3773	60368	2	6288	12576	133	3215	427595	120	3215	385800	21	3215	67515	953854
Southwest - Northeast	10	3773	37730	4	6288	25152	148	3215	475820	257	3215	826255	65	3215	208975	1573932
South - North	25	3773	94325	3	6288	18864	0	0	0	0	0	0	0	0	0	113189
West - East	14	3773	52822	4	6288	25152	0	0	0	0	0	0	0	0	0	77974
TOTAL	65	15092	**245245**	13	25152	**81744**	281	6430	**903415**	377	6430	**1212055**	86	6430	**276490**	**2718949**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	20	3773	75460	2	6288	12576	115	3215	369725	102	3215	327930	37	3215	118955	904646
Southwest - Northeast	10	3773	37730	5	6288	31440	130	3215	417950	238	3215	765170	94	3215	302210	1554500
South - North	41	3773	154693	3	6288	18864	0	0	0	0	0	0	0	0	0	173557
West - East	22	3773	83006	4	6288	25152	0	0	0	0	0	0	0	0	0	108158
TOTAL	93	15092	**350889**	14	25152	**88032**	245	6430	**787675**	340	6430	**1093100**	131	6430	**421165**	**2740861**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	11	3773	41503	1	6288	6288	0	3215	0	0	3215	0	0	3215	0	47791
Southwest - Northeast	8	3773	30184	0	6288	0	0	3215	0	0	3215	0	0	3215	0	30184
South - North	11	3773	41503	0	6288	0	0	0	0	0	0	0	0	0	0	41503
West - East	11	3773	41503	0	6288	0	0	0	0	0	0	0	0	0	0	41503
TOTAL	41	15092	**154693**	1	25152	**6288**	0	6430	0	0	6430	0	0	6430	0	**160981**
	ORIGINAL															
Southeast - Northwest	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
Southwest - Northeast	0	3773	0	0	6288	0	0	3215	0	0	3215	0	0	3215	0	0
South - North	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
West - East	0	3773	0	0	6288	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	15092	0	0	25152	0	0	6430	0	0	6430	0	0	6430	0	**0**
TOTAL	346	**45276**	**350889**	48		**88032**	984		**787675**	1480		**1093100**	378		**421165**	**10744312**

Calculation Matrix – METHOD 02 – Total Gas consumption 2050 (just MIXTURES)
(measures were introduced equally in every type of building and orientation)

2050 - CO_2 EMISSIONS (solar)

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	3 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	37	3523	130351	4	5871	23484	118	2366	279188	72	2256	162432	50	1770	88500	683955
Southwest - Northeast	25	3493	87325	6	5821	34926	160	2334	373440	511	2243	1146173	111	1739	193029	1834893
South - North	54	3512	189648	2	5854	11708	0	0	0	0	0	0	0	0	0	201356
West - East	31	3493	108283	8	5821	46568	0	0	0	0	0	0	0	0	0	154851
TOTAL	147	14021	**515607**	20	23367	**116686**	278	4700	**652628**	583	4499	**1308605**	161	3509	**281529**	**2875055**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	3446	55136	2	5744	11488	43	2349	101007	30	2235	67050	21	1754	36834	271515
Southwest - Northeast	10	3416	34160	4	5693	22772	58	2320	134560	167	2206	368402	65	1725	112125	672019
South - North	25	3438	85950	2	5730	11460	0	0	0	0	0	0	0	0	0	97410
West - East	14	3416	47824	5	5693	28465	0	0	0	0	0	0	0	0	0	76289
TOTAL	65	13716	**223070**	13	22860	**74185**	101	4669	**235567**	197	4441	**435452**	86	3479	**148959**	**1117233**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	20	3141	62820	2	5235	10470	25	2014	50350	12	1914	22968	37	1419	52503	199111
Southwest - Northeast	10	3123	31230	5	5205	26025	40	1995	79800	148	1897	280756	94	1399	131506	549317
South - North	41	3132	128412	3	5219	15657	0	0	0	0	0	0	0	0	0	144069
West - East	22	3123	68706	4	5205	20820	0	0	0	0	0	0	0	0	0	89526
TOTAL	93	12519	**291168**	14	20864	**72972**	65	4009	**130150**	160	3811	**303724**	131	2818	**184009**	**982023**
	MORE SOLAR -lamps															
Southeast - Northwest	0	0	0	0	0	0	90	1770	159300	90	1660	149400	0	0	0	308700
Southwest - Northeast	0	0	0	0	0	0	90	1739	156510	90	1626	146340	0	0	0	302850
TOTAL	0	0	0	0	0	0	180	3509	**315810**	180	3286	**295740**	0	0	0	**611550**
	MORE SOLAR -windows															
Southeast - Northwest	0	0	0	0	0	0	90	1754	157860	90	1639	147510	0	0	0	305370
Southwest - Northeast	0	0	0	0	0	0	90	1725	155250	90	1610	144900	0	0	0	300150
TOTAL	0	0	0	0	0	0	180	3479	**313110**	180	3249	**292410**	0	0	0	**605520**
	MORE SOLAR -insulation															
Southeast - Northwest	0	0	0	0	0	0	90	1419	127710	90	1319	118710	0	0	0	246420
Southwest - Northeast	0	0	0	0	0	0	90	1399	125910	90	1302	117180	0	0	0	243090
TOTAL	0	0	0	0	0	0	180	2818	**253620**	180	2621	**235890**	0	0	0	**489510**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	11	2859	31449	1	4765	4765	0	1889	0	0	1806	0	0	1889	0	36214
Southwest - Northeast	8	2820	22560	0	4700	0	0	1873	0	0	1792	0	0	1873	0	22560
South - North	11	2851	31361	0	4752	0	0	0	0	0	0	0	0	0	0	31361
West - East	11	2820	31020	0	4700	0	0	0	0	0	0	0	0	0	0	31020
TOTAL	41	11350	**116390**	1	18917	**4765**	0	3762	0	0	3598	0	0	3762	**0**	**121155**
	ORIGINAL															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TOTAL	346	12519	**291168**	48		**72972**	984		**130150**	1480		**303724**	378		**184009**	**6802046**

Calculation Matrix – Total Gas consumption 2050 applying Solar Panels

(electricity consumption will just vary with the 4,2% PV's production, and there was no need for calculation matrix as only totals were recalculated)

2050 - GAS CONSUMPTION (solar)

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	3 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
Southeast - Northwest	37	3773	139601	4	6288	25152	118	3215	379370	72	3215	231480	50	252	12600	788203
Southwest - Northeast	25	3773	94325	6	6288	37728	160	3215	514400	511	3215	1642865	111	252	27972	2317290
South - North	54	3773	203742	2	6288	12576	0	0	0	0	0	0	0	0	0	216318
West - East	31	3773	116963	8	6288	50304	0	0	0	0	0	0	0	0	0	167267
TOTAL	147	15092	**554631**	20	25152	**125760**	278	6430	**893770**	583	6430	**1874345**	161	504	**40572**	**3489078**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
Southeast - Northwest	16	3773	60368	2	6288	12576	43	3215	138245	30	3215	96450	21	252	5292	312931
Southwest - Northeast	10	3773	37730	4	6288	25152	58	3215	186470	167	3215	536905	65	252	16380	802637
South - North	25	3773	94325	2	6288	12576	0	0	0	0	0	0	0	0	0	106901
West - East	14	3773	52822	5	6288	31440	0	0	0	0	0	0	0	0	0	84262
TOTAL	65	15092	**245245**	13	25152	**81744**	101	6430	**324715**	197	6430	**633355**	86	504	**21672**	**1306731**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
Southeast - Northwest	20	3773	75460	2	6288	12576	25	3215	80375	12	3215	38580	37	252	9324	216315
Southwest - Northeast	10	3773	37730	5	6288	31440	40	3215	128600	148	3215	475820	94	252	23688	697278
South - North	41	3773	154693	3	6288	18864	0	0	0	0	0	0	0	0	0	173557
West - East	22	3773	83006	4	6288	25152	0	0	0	0	0	0	0	0	0	108158
TOTAL	93	15092	**350889**	14	25152	**88032**	65	6430	**208975**	160	6430	**514400**	131	504	**33012**	**1195308**
	MORE SOLAR -lamps															
Southeast - Northwest	0	0	0	0	0	0	90	252	22680	90	3215	289350	0	0	0	312030
Southwest - Northeast	0	0	0	0	0	0	90	252	22680	90	3215	289350	0	0	0	312030
TOTAL	0	0	0	0	0	0	180	504	**45360**	180	6430	**578700**	0	0	0	**624060**
	MORE SOLAR -windows															
Southeast - Northwest	0	0	0	0	0	0	90	252	22680	90	3215	289350	0	0	0	312030
Southwest - Northeast	0	0	0	0	0	0	90	252	22680	90	3215	289350	0	0	0	312030
TOTAL	0	0	0	0	0	0	180	504	**45360**	180	6430	**578700**	0	0	0	**624060**
	MORE SOLAR -insulation															
Southeast - Northwest	0	0	0	0	0	0	90	252	22680	90	3215	289350	0	0	0	312030
Southwest - Northeast	0	0	0	0	0	0	90	252	22680	90	3215	289350	0	0	0	312030
TOTAL	0	0	0	0	0	0	180	504	**45360**	180	6430	**578700**	0	0	0	**624060**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEAT RECOVER															
Southeast - Northwest	11	3773	41503	1	6288	6288	0	3215	0	0	3215	0	0	3215	0	47791
Southwest - Northeast	8	3773	30184	0	6288	0	0	3215	0	0	3215	0	0	3215	0	30184
South - North	11	3773	41503	0	6288	0	0	0	0	0	0	0	0	0	0	41503
West - East	11	3773	41503	0	6288	0	0	0	0	0	0	0	0	0	0	41503
TOTAL	41	15092	**154693**	1	25152	**6288**	0	6430	0	0	6430	0	0	6430	**0**	**160981**
	ORIGINAL															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TOTAL	346	15092	350889	48		88032	984		208975	1480		514400	378		33012	8024278

Calculation Matrix – Total CO2 Emissions 60% Scenario – MIXTURES and Solar Panels

(PV's calculated with the totals and 45% were reduced)

60% Scenario- all houses with gas heating and solar panels - CO_2 EMISSIONS

FACADE ORIENTATION	SEMI-DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	DETACHED HOUSES	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	4 floors, 8 flats	per house kg CO2/kWh	Total kg CO2/kWh	3 floors, 6 flats	per house kg CO2/kWh	Total kg CO2/kWh	TOTAL kg CO2/kWh
	EFFICIENT EQUIPMENT															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	EFFICIENT EQUIPMENT and LAMPS															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	EFFICIENT EQUIPMENT, LAMPS and WINDOWS															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS and INSULATION															
TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	EFFICIENT EQUIPMENT, LAMPS, WINDOWS, INSULATION and HEATING with gas															
Southeast - Northwest	84	1557	130788	9	3063	27567	456	1289	587784	384	1206	463104	108	1289	139212	1348455
Southwest - Northeast	52	1535	79820	15	3027	45405	528	1273	672144	1096	1192	1306432	270	1273	343710	2447511
South - North	132	1552	204864	7	3056	21392	0	0	0	0	0	0	0	0	0	226256
West - East	78	1535	119730	17	3027	51459	0	0	0	0	0	0	0	0	0	171189
TOTAL	346	6179	535202	48	12173	145823	984	2562	1259928	1480	2398	1769536	378	2562	482922	**4193411**
TOTAL	346		535202	48		145823	984		1259928	1480		1769536	378		482922	**4193411**

APPENDIX 04

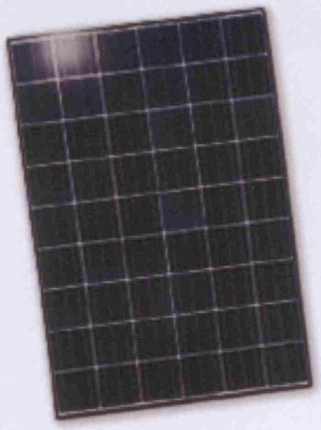
Photovoltaic's (Donauer 2008)

KD210GH-2P / KD205GH-2P

Os excepcionais níveis de qualidade e eficiência alcançados nos módulos policristalinos Kyocera, devem-se sobretudo a um exaustivo trabalho de pesquisa, ao desenvolvimento contínuo dos processos de produção e aos altos níveis de automatização conseguidos.

As células solares integradas possuem um tamanho standard de 15,6 cm x 15,6 cm e alcançam um elevado nível de eficiência que atinge os 16%, garantindo assim um elevado rendimento anual de energia através de um sistema fotovoltaico.

Para proteção contra condições climatéricas adversas, as células solares são inseridas entre um vidro reforçado (resistente ao granizo mediante norma IEC 61215 testado pela TÜV) e uma película de EVA e isolado no verso por láminas PET. O laminado está inserido numa moldura de alumínio bastante estável e de fácil montagem.



A parte de trás da caixa de ligações está equipada com diodos de bypass que eliminam o risco de sobreaquecimento individual das células solares (efeito hot spot). Os cabos solares asseguram uma instalação flexível e a caixa de ligações simplifica a instalação de sistemas isolados.

Exemplos de aplicações

- Sistemas ligados à rede
- Sistemas solares domésticos
- Sistemas solares públicos e industriais
- Centrais de energia solar

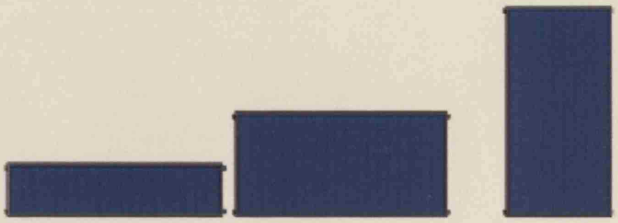
	KD210GH-2P	KD205GH-2P
Potência nominal com Pmáx (W)	210 (+5/-5%)	205 (+5/-5%)
Tensão MPP (V)	26,6	26,6
Corrente em MPP (A)	7,90	7,71
Tensão de sistemas máx. (V)	1000	1000
Voltagem de circuito aberto (V)	33,2	33,2
Corrente de curto-circuito (A)	8,58	8,36
Coeficiente de temperatura VOC (V /°C)	-0,120	-0,120
Coeficiente de temperatura ISC (mA /°C)	5,02	5,02
Dimensões L x A x C (mm)	1500 x 990 x 36	1500 x 990 x 36
Peso (kg)	18,5	18,5
Garantia de funcionamento do fabricante* (anos)	20	20
Garantia do produto do fabricante (anos)	2	2
Certificado	IEC 61215 ed. 2, IEC 61730, TÜV, classe de protecção II, CE	IEC 61215 ed. 2, IEC 61730, TÜV, classe de protecção II, CE
*	*10 anos a 90%, 20 anos a 80% da potência mínima especificada	

Salvo erro e alterações técnicas. As imagens podem diferir do original.
Vigoram as actuais condições de garantia do respectivo fabricante.

DONAUER SOLAR SYSTEMS

IMMOSOLAR
EnergyManagement

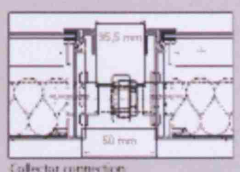
Technical data



Flat collector	IS-PRO 1Q	IS-PRO 2Q	IS-PRO 2H
Dimensions			
Length	450.0 mm	1045.4 mm	2045.4 mm
Width	2045.4 mm	2045.4 mm	1045.4 mm
Height	77.0 mm	77.0 mm	77.0 mm
Weight/static weight	18 kg / 18.6 kg	37 kg / 38.0 kg	37 kg/38.0 kg
Gross surface	0.920 m²	2.138 m²	2.138 m²
Absorption surface	0.811 m²	2.003 m²	2.003 m²
Aperture surface	0.813 m²	2.004 m²	2.004 m²
Effective surface utilisation	88.15 %	93.75 %	93.75 %

Frame	Extruded aluminium section, formed from a single piece with a joint on the lower side; anodised frame and glass covering strip, frame section with ventilation holes, integrated connection thread for substructure		
Glass	3.2 mm ESG glass SXT Solite, surrounded by high-temperature resistant EPDM seal, glass and seal clipped together with aluminium strip on the border		
Back plate	Stucco Alu		
Absorber	TINOX, induction welded, collecting pipe Ø 22 mm (horizontal), lattice pipes Ø 8 mm (vertical)		
Lattice pipes 8 mm	20	20	10
Insulation	40 mm mineral wool		
Connections	¾" ext. thread, ¾" union nut, high temperature resistant flat seal up to 250°C		
Installation	collector spacing, 35.5 mm when installed		
On-roof	hanger bolt system or roof bracket system or flat-roof free frame mounting		
Façade	single assembly with the IS-PRO aluminium T section		
In-roof	ready-to-install in-roof installation set		
Expansion joints	after the 3rd or 4th collector		after the 6th or 8th collector

Minimum collector energy gain	525 kWh/m²y		
Testing Switzerland / Austria	SPF (Switzerland)	Arsenal Research (Austria)	
Testing Spain / Portugal	INTA (Spain)	CERTIF (Portugal)	
Part no.	15000016	15000018	15000017



Collector connection

IMMOSOLAR Vertriebs GmbH
Waldecker Strasse 8
D-64546 Moerfelden-Walldorf
Tel.: +49(0)6105-27320
Fax: +49(0)6105-273210
email: germany@immosolar.info
www.immosolar.com

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